

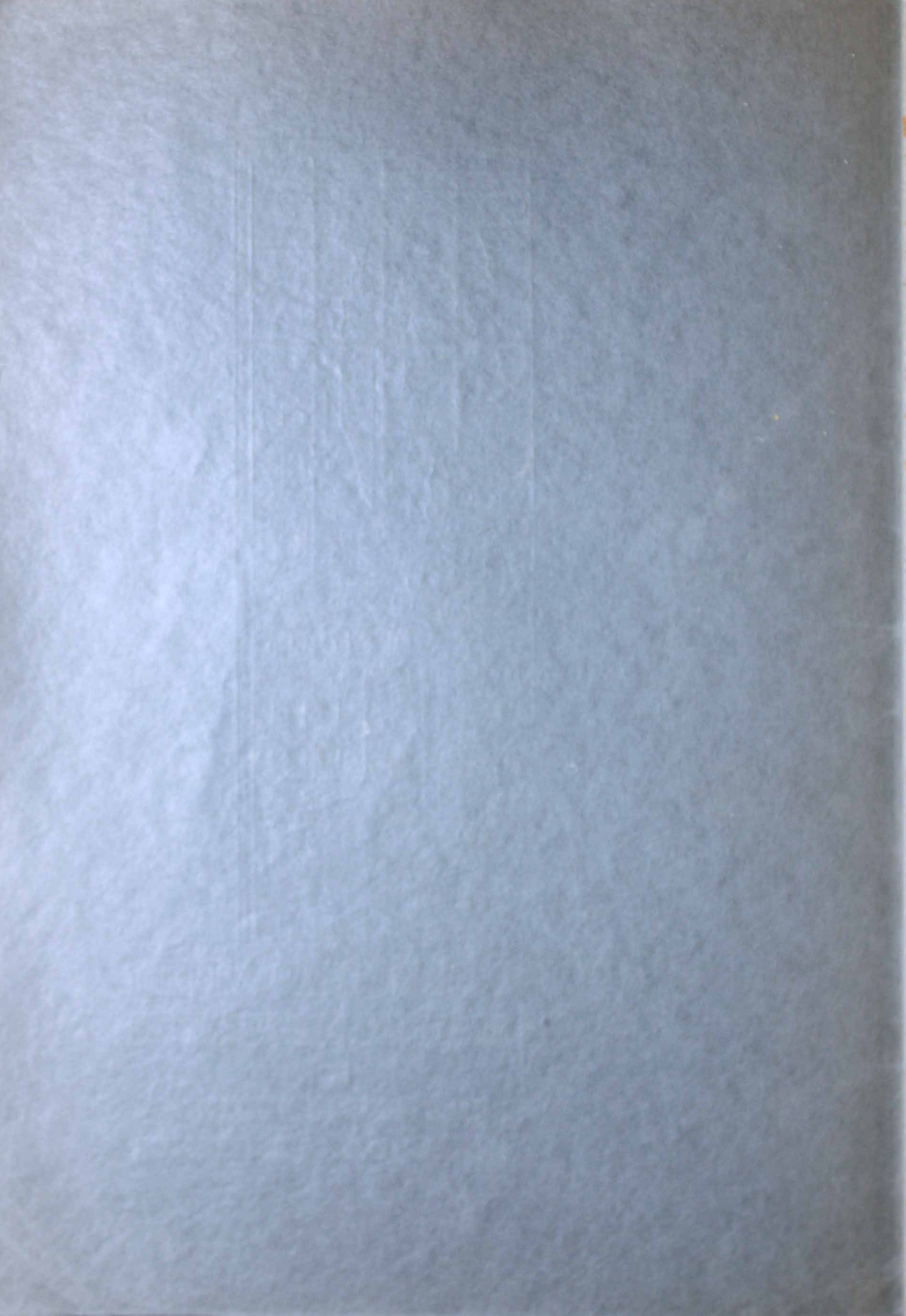
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REFRIGERATED DRINKING WATER

FOR

MILLS · PUBLIC BUILDINGS
HOTELS · OFFICE BUILDINGS



REFRIGERATED DRINKING WATER

for

Mills, Factories, Shops, Hotels,
Hospitals, Schools, Institutions,
Public and Office Buildings,
Stores, etc.



Reg. U. S. Pat. Off.

A. I. A. Classification 34i3

ARMSTRONG CORK & INSULATION COMPANY
PITTSBURGH, PA.

Branches in the Principal Cities

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Armstrong Cork & Insulation Company
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One of the fountains of the refrigerated drinking water system in the plant of the Atlas Portland Cement Company, Hannibal, Mo., showing one method of "looping" to provide continuous circulation. The lines are insulated with Nonpareil Cork Covering

A Good Drink of Water



ALL who provide buildings of any kind for human occupancy are under the necessity also of providing three essential elements without which man cannot live properly or work efficiently, namely, light, air, and water. Abundant as these are in Nature, the artificial conditions of modern building require special provision in order that they may be available in adequate quantity and of good quality.

While the illuminating engineer and the ventilating engineer have made invaluable contributions to the improvement of comfort, health, and efficiency through the proper distribution of light and air, the matter of drinking water, though by no means neglected, has not until recently received as careful attention as its importance deserves. The supply may be wells, piped city water, ice water tanks, or bucket-and-dipper distribution, and except in the most modern buildings, the system, if any, is usually haphazard.

Good Water a Necessity

Good water is a necessity; plenty of water a positive benefit. Most of us drink too little of it, principally because it is not always as readily accessible as it should be, and often because we are not sure of the source and quality or find the temperature distasteful. Guests in hotels, tenants of office buildings and apartments, visitors to public buildings, students in schools, and workers in shops, stores, mills, and factories are entitled to easy access to cool, wholesome, palatable water. It is just as much to the interest of the owner or management to provide such supply as it is to furnish good light, fresh air, and proper lavatory facilities.

Good Water and Good Will

It is not enough merely to supply water that can be used for drinking. When a man is thirsty, he wants *good* water, cold enough to refresh and satisfy. If what he gets is warm, or in any way distasteful or disagreeable, he resents it, and his resentment, if continued, may easily become a fruitful source of trouble.

The hotel guest who must choose between drinking the lavatory water or ringing—and waiting—for ice water in a pitcher will very likely go to another hotel on his next trip, and spread his dissatisfaction among others. Cold, clear water instantly available in a hotel room is a source of good will which no management can afford to overlook. The same is true of public and office buildings.

In industrial plants, the failure to furnish a proper supply of drinking water has even more serious results, for it may easily be the direct cause of lowered production through inefficiency and sickness

layoffs, and is certain to create discontent which leads to ill will and high labor turnover. A mill or factory, on the other hand, in which good, cold water is always easily available will, other things being equal, inevitably attract and hold the better class of employees and profit accordingly from their good will and contentment.

The supply of good drinking water is therefore not only a humanitarian policy, but it is also economically profitable. A well-designed system actually costs less to operate than the haphazard methods often used, and pays returns which, while they may be difficult to estimate, are none the less real and substantial.

Pioneering a New Field

Some 20 years ago this Company became interested in drinking water supply and undertook a thorough investigation. They realized, as did many building and industrial managers, that the methods in use were crude and uneconomical. Their familiarity with the field of refrigeration suggested the remedy and their natural desire to develop a new market for Nonpareil Cork Covering supplied the incentive.

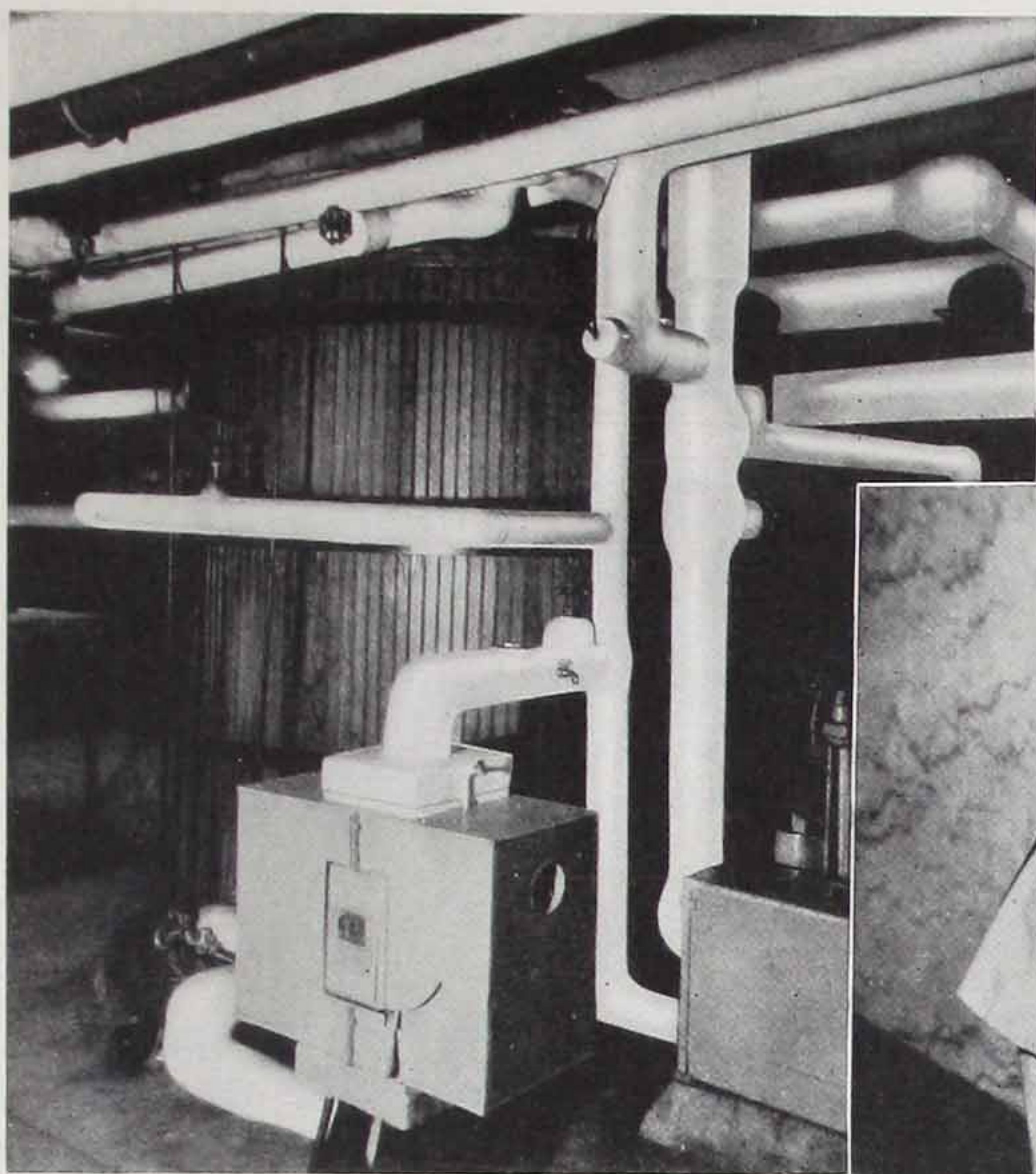
At that time, no one knew how much water industrial and office workers were consuming, and no one outside of medical circles knew how much they *should* consume to maintain health and efficiency, or what the temperature of drinking water should be. The whole subject was shrouded in misinformation and indifference. There was nothing to work from in the way of records or accurate knowledge.

From medical societies and health laboratories, the Company's engineers ascertained the amount of water normally required by the human body under different working and temperature conditions, and the temperature at which water should be drunk to be most inviting, refreshing and wholesome. Through the cooperation of a number of progressive industrial executives, they investigated conditions in scores of mills and factories insofar as these had a bearing on water supply. They checked the amount of water consumed; observed the reactions of workers to water of different temperatures; measured the distances from work benches to supply; recorded the time spent in going to and from the drinking places; calculated the cost of water supply under the many systems in use; in short, they did what had never been done before—made a complete and detailed survey of the whole field of industrial drinking water distribution. And with these data in hand, they then set about to devise an efficient, safe, and economical system to replace the haphazard, expensive, and uneconomical methods generally used.

Development of the Modern System

Simple as is the present refrigerated system, its development came only after several years of intensive research and experimental work. Volume, velocities, pipe sizes and piping layout, outlets and their location, pump and tank equipment, refrigeration and insulation, all were worked out on a basis of maximum efficiency and economy. So thoroughly





The cooling and pumping equipment for the drinking water system of the General Motors Building, Detroit. Nonpareil Cork Covering, canvas and paint finish

One of the corridor fountains in the General Motors Building



was this task accomplished and so completely was every phase of the problem covered that much of the present knowledge of refrigerated drinking water systems is based on the facts disclosed, the methods developed, and the data supplied through the work begun and continued by this Company.

The drinking water systems in use today in hundreds of buildings and industrial plants are designed on the principles thus developed, and all in which those principles have been rigidly followed are operating exactly as planned, thus testifying to the inherent correctness of design and calculations. Some of these have been in continuous operation for as long as 20 years without alteration and with only negligible repairs or replacements. Cost data extending over all these years as well as the beneficial results on health and morale have fully borne out every expectation and amply justified the laborious and painstaking research and development work.

Methods Commonly Used and Their Faults

When housing and industry began to spread beyond the point where everyone could go to the pump and get a drink, the simplest expedient was to utilize what Nature or the community provided. Water was taken from a well and carried to tanks more or less centrally located, or direct to the workers by the bucket-and-boy route. It was dispensed by means of a cup, dipper, or glass, one for all—democratic, but neither sanitary nor inviting—and was cooled, if at

all, by simply dropping a lump of ice into the tank or bucket, with the result that in hot weather or in mills, smelters, heat-treating plants, etc., cramps and sickness were not infrequently caused by too free indulgence.

A variation of the "bucket-and-boy" distribution commonly used in mills was the "pitcher-and-boy" method even now found in many hotels—a bit more refined, but essentially the same and almost equally unsatisfactory.

Another commonly used system is the piping of city water under line pressure, or the pumping of well water through distributing lines about the building or plant, with little or no effort at temperature regulation. In some localities where well water is cold enough at the source it affords a satisfactory supply provided the lines are thoroughly insulated to prevent too great an increase in temperature in distribution.

Bucket Distribution

The unsanitary features of any method of distribution by carrier in open vessels, even though individual cups may be used, need little comment. Contamination from dust, the hands, the vessel itself, or the ice in it is almost unavoidable. It has the further disadvantage of not being readily available; one has to drink, not when he wants to, but when the water comes around, and the tendency is not to drink at all or to drink entirely too much at one time. In fact, the system is so obviously bad that it is being rapidly discarded everywhere except in outdoor work, such as road building, where no other method is practicable.

Putting ice in the water, besides making it too cold to be healthful, is not sanitary. Even if the ice itself is pure, it has to be broken up and handled and is usually none too clean by the time it gets into the water.

City Water

Very often city water is not entirely free from objectionable taste or odor, and almost never in summer is it cool enough to be palatable. Consequently it is consumed rather reluctantly and only in such quantities as will serve to relieve thirst, and by no means freely enough to be refreshing and satisfying and as beneficial as the copious use of good water is known to be. Lassitude and constipation with its attendant ills are commonly traceable directly to a deficiency of water in the system, and this in turn to the unattractiveness of the water itself. City supply also involves a great deal of waste of both water and time. In the effort to let the water "run cool" many gallons are wasted, and many minutes lost.

Cooling Tanks

Drinking water tanks placed about a building do not meet the requirements. Tanks with adequate provision for cooling the water are somewhat expensive and are seldom



used in sufficient number to be readily accessible. In shops and mills they cause a good deal of waste of time in going back and forth and in "visiting" in the groups that tend to gather about them.

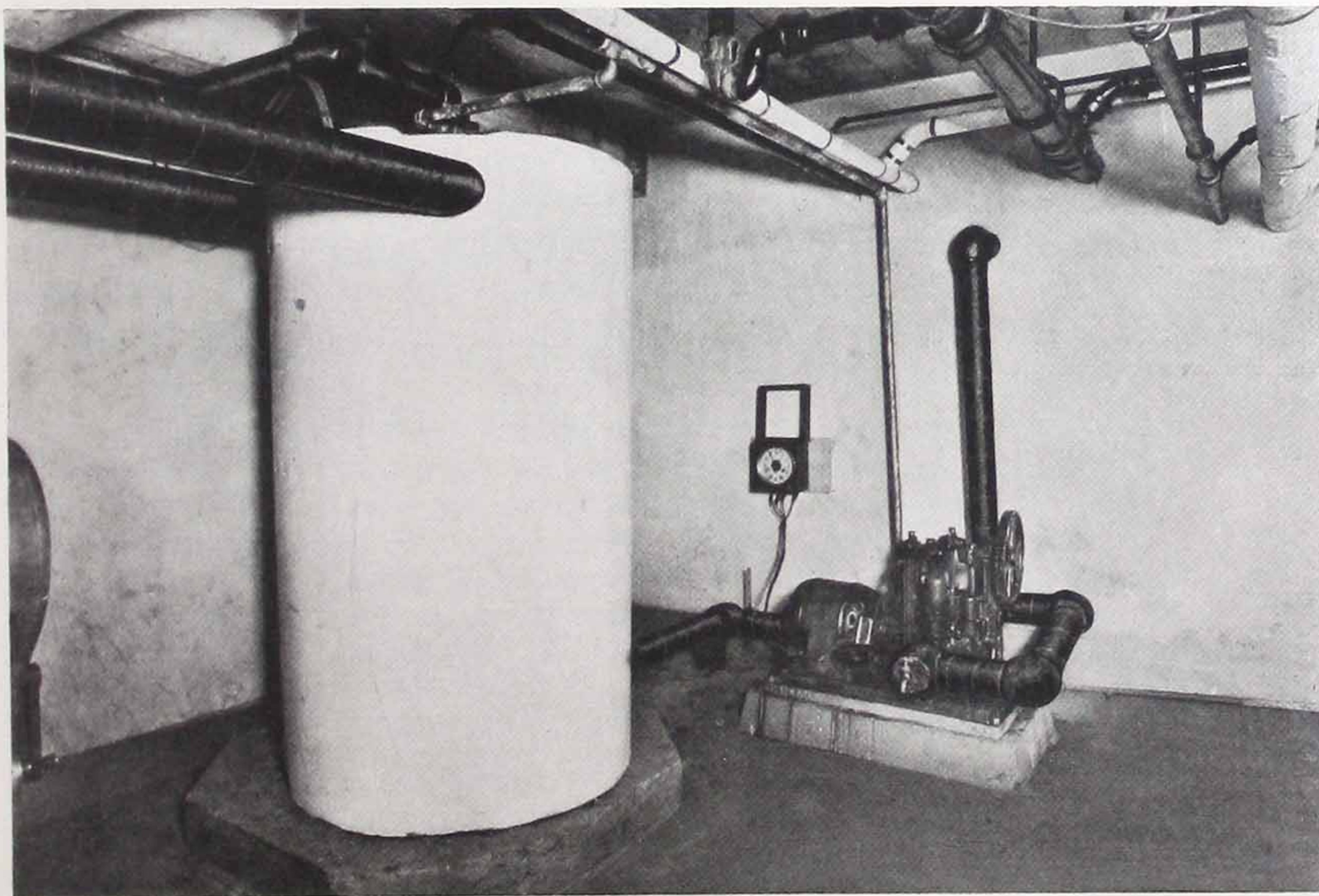
Where ice is used for cooling, either in the water or surrounding the water chamber or coils, the temperature of the water is too low to be healthful and safe. This is almost invariably the case with the waterbottle or tank coolers commonly used in offices, small shops, and stores.

Moreover, all such devices have to be serviced, that is, constantly supplied with water and ice, a feature which, because of its cost, inconvenience, and uncertainty, makes their use impractical in industrial plants, large buildings, or wherever water is consumed in considerable quantities.

The Refrigerated Circulating System

After observing carefully for many years the various efforts to work out this problem in all kinds of buildings, architects and engineers are virtually unanimous in their adoption of the mechanically refrigerated circulating system as not only the most satisfactory, but the only really efficient and economical method of supplying and distributing properly cooled drinking water in large buildings. It meets every requirement to the fullest extent possible:

(a)—It provides for an adequate supply of pure, clear, wholesome water;



Cooling tank, pump and Nonpareil Cork covered lines in the basement of the Y. W. C. A. Building at Houston, Texas

(b)—It cools the water to exactly the proper temperature and maintains that temperature within the permissible range throughout the complete circuit;

(c)—It conveys the water to any height or over any area to any number of outlets wherever located;

(d)—It is adapted for any desired type of outlet—faucet or fountain;

(e)—It is extremely economical of water. In whatever quantity it may be consumed, practically none need be wasted;

(f)—It is economical of mechanical power, requiring comparatively little equipment for circulation, storage, and refrigeration;

(g)—The equipment for both supply and distribution occupies very little space in either the power plant or throughout the building;

(h)—The constant, easily accessible supply of attractive and refreshing water contributes to the convenience and pleasure of guests, tenants, and visitors in hotels, office buildings, etc., and promotes health and contentment among industrial workers;

(i)—Since outlets can be easily located at almost any point, the system conserves time and effort on the part of the operatives;

(j)—It is an extremely elastic system and can be almost indefinitely extended with little additional equipment, or as readily contracted if necessary.

(k)—The initial cost of installation is moderate and reasonable, and the cost of maintenance very low. Operating expense, or cost of distribution, is less than for any other adequate system.

Proof from Experience

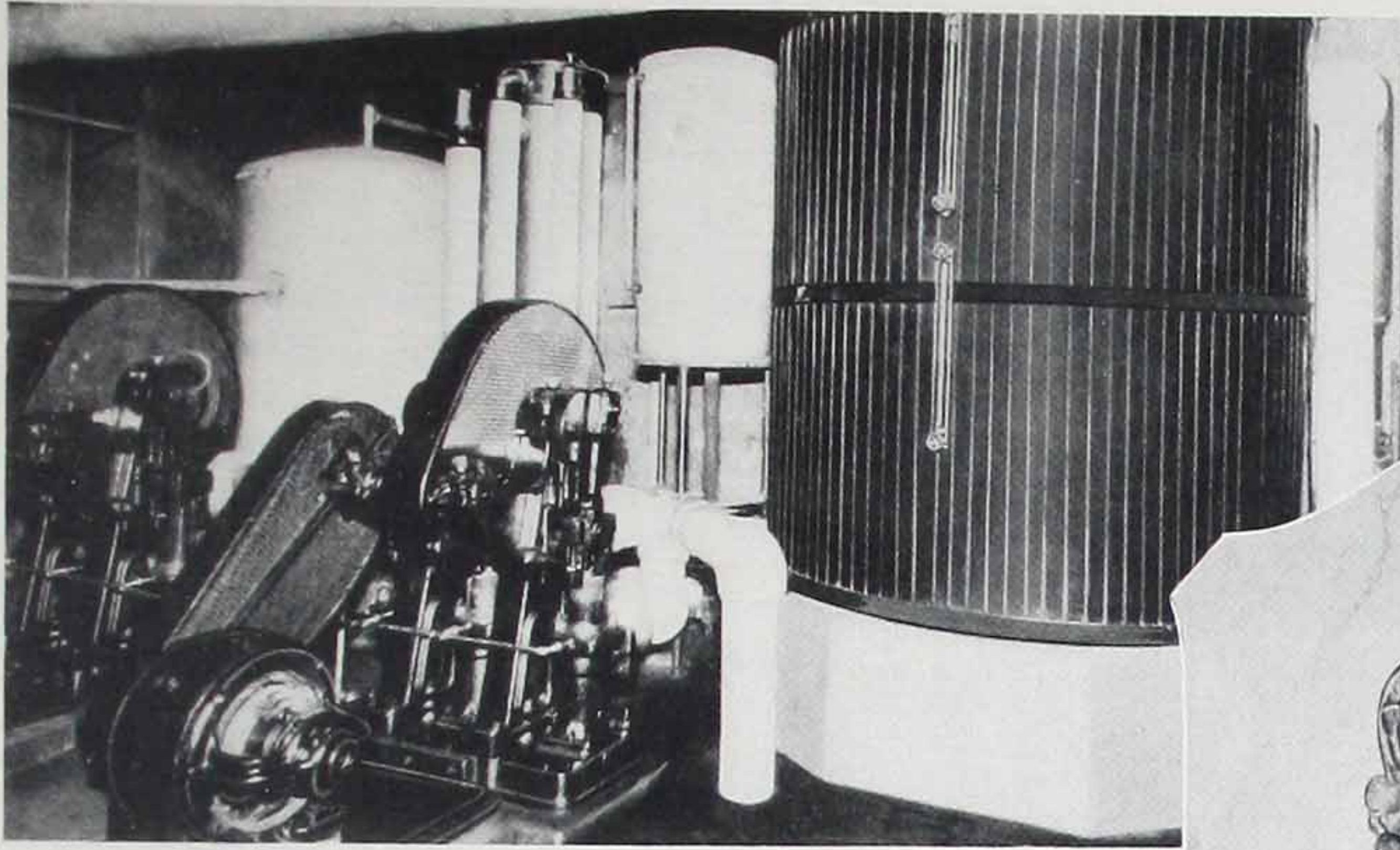
No more convincing evidence in support of these statements could be asked than is furnished by the following report of a survey made by the A. C. Nielsen Company, Chicago, engineers, in a metal working plant in Pittsburgh, Pa. (Name furnished on request). The report is certified by the assistant chief engineer of the plant.

“In a plant such as ours, where a large percentage of the 1,400 employees are working in the mill and being subjected to high temperatures, the problem of supplying them with drinking water is very important.

“Until about seven years ago we had five ice tanks scattered through the mill in addition to a flowing well. Since the ice tanks were not available to all of the men it was necessary to keep buckets of water at various points. The buckets and cups were far from sanitary.

Old System Unsatisfactory

“The water was of uneven temperature. When the ice tanks were full the water was ice cold. This was very unhealthful for the men because when a man became heated up from his work and then drank ice cold water, his stomach became chilled, with consequent danger of cramps.



*One of the beautiful
bronze drinking
fountains in the
City-County
Building*

Cooling, pumping and storage equipment for the drinking water system of the City-County Building, Pittsburgh, Pa. The Nonpareil Cork Covering on the lines is finished with canvas and painted, and the storage tank is wood lagged over the cork insulation



"When the ice in the tanks was melted the water was lukewarm and not palatable. Under these conditions the men probably did not drink enough water to keep their bodies in the best of condition. The cost of maintaining this system, as shown on the accompanying cost sheet, was over \$2,000.00 per year, and the results were far from satisfactory.

"After a careful study of the matter, we installed a modern refrigerated drinking water system in the hope of correcting these conditions. We have a 10-ton refrigerating machine arranged to refrigerate a tank of water. This water is circulated to the drinking fountains located throughout the various buildings, through two insulated pipe lines by two circulating pumps. There are 32 drinking fountains, about half of which are located on each of the two divisions of the circulating pipes. There is about 2,500 feet of pipe in each of the lines.

Nonpareil Cork Covering Insures Excellent Results

"The pipe lines are insulated with Nonpareil Cork Covering made by the Armstrong Cork & Insulation Company, Pittsburgh, Pa. This material has an unusually high insulating value which insures delivery of water at the proper temperature—a factor essential to the success of such a system. The system was designed to cool 188 gal. of water from 80° F. to 40° F. per hour, and 667 gal. of circulated water per hour from 50° to 40°. In other words the machine not only has to cool the makeup water, but it must also cool the return water to the temperature desired.

"The circulating water temperature in our system averages about 45° F. at the fountain nearest the tank, and at the last fountain on each of the 2,500 ft. lines, which is the fountain nearest the return end of the line, the temperature averages about 50° F. This increase of only 5° F. in 2,500 feet represents excellent performance because the pipes are run through the mill above the floor where they are subjected to the furnace heat.

Costs Only \$1.00 Per Year Per Man

"As shown on the attached cost sheet, the cost of operation is about \$1,395.00 per year or \$1.00 per man per year, which is very reasonable.

"In comparison with the former cost, the annual saving is \$671.50, which is a 32% reduction in the cost of supplying drinking water. This saving was, however, not the primary reason for installing the new system; in fact, we would have installed it for welfare reasons even if the operating cost had been greater than that of the old method.

Reduction in Cramps

"We have not included any saving in working time of the men due to their spending less time away from their work to get a drink of water, because in our case the men in the mill are spelled and can then get a drink of water. In other plants an appreciable saving in time might be effected.

"We believe that the refrigerated drinking water plays an important part in the successful operation of the plant. The main results are as follows:

1. An abundant supply of palatable, wholesome water.
2. An even temperature of water, thus eliminating cramps caused by water that is too cold.
3. Sanitary fountains, resulting in less sickness and disease.
4. More satisfied workmen.

Operating Cost of Refrigerated Drinking Water System

Depreciation—\$10,000.00 ÷ 20 yrs. life.....	\$ 500.00
*Average interest at 6%— $\frac{21}{20} \times \frac{\$10,000.00 \times .06}{2}$	315.00
Repairs and maintenance.....	200.00
Ammonia and oil.....	50.00
Power—22,000 K.W.H. at \$.015.....	330.00
Total yearly cost of operation.....	\$1,395.00
Cost per man per year—\$1,395.00 ÷ 1,400 men.....	\$1.00

Operating Cost of Former Method of Water Supply

Depreciation on 5 tanks—\$500.00 ÷ 10 years.....	\$ 50.00
*Average interest at 6%— $\frac{11}{10} \times \frac{\$500.00 \times .06}{2}$	16.50
Ice.....	1,500.00
Labor.....	450.00
Repairs.....	50.00
Former cost of water supply per year.....	\$2,066.50
Yearly cost of present refrigerated system.....	1,395.00
Net saving per year.....	\$ 671.50

* Allowing for interest earned by depreciation reserve.

The following is a summary of a similar report by the same engineers on a group of textile mills operated by the Chadwick-Hoskins Company, Charlotte, N. C.:



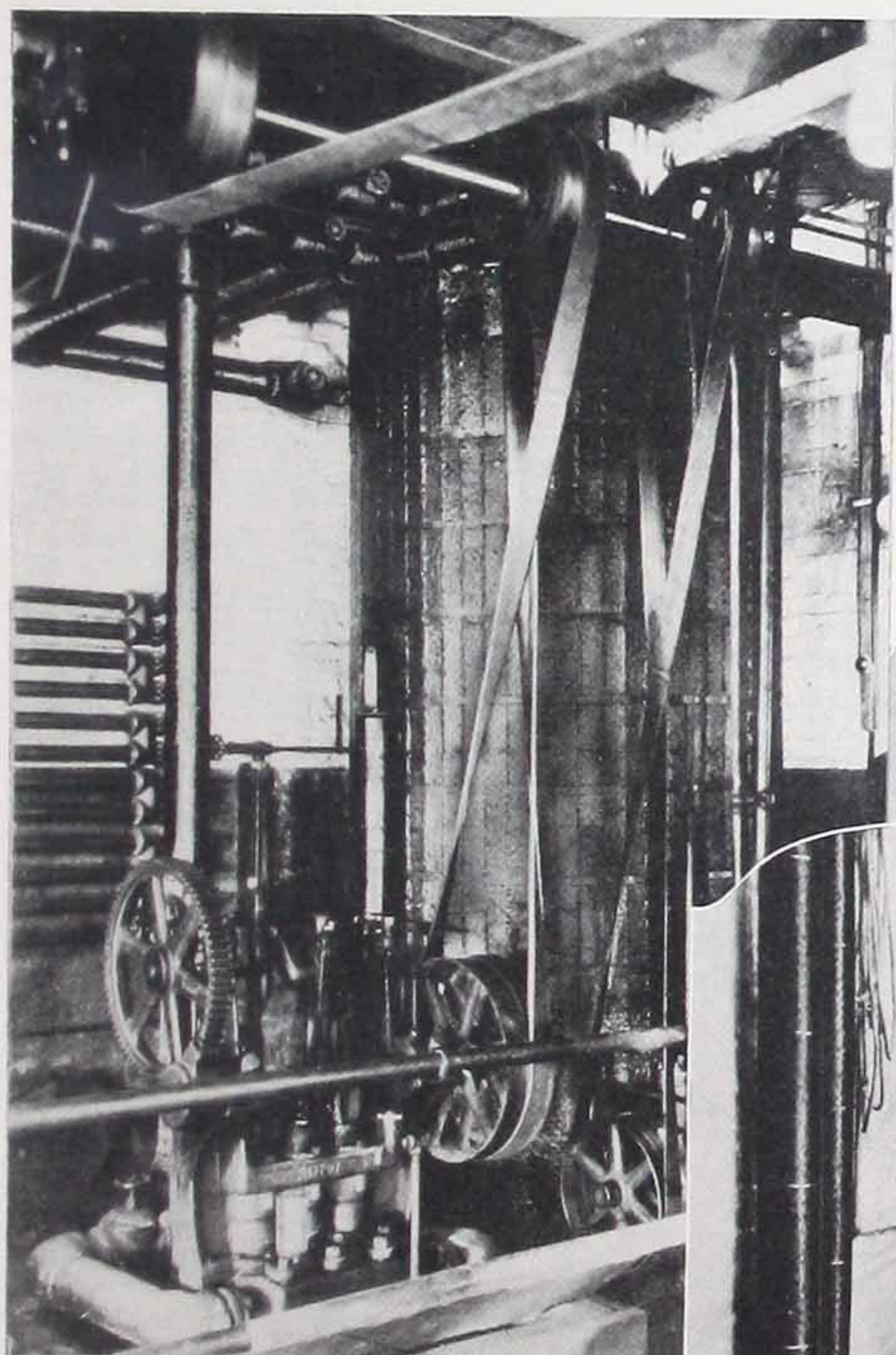
Until recently this company supplied drinking water to approximately 1,000 employees in 5 of its mills by carrying it in buckets from wells, using 3 men for 2 hours per day in each mill. At the low labor cost of 20 cents per hour, water distribution was costing \$1800.00 a year. As the water came from the wells at 64 to 68 degrees, it was not very satisfying even when perfectly fresh; after standing for 15 minutes, the operatives wouldn't drink it at all. Ice in the pails would have been dangerous to health.

The company installed a mechanically refrigerated and circulated drinking water system with 4 to 5 fountains in each mill. All lines and refrigerated equipment were insulated with Nonpareil Cork Covering to reduce heat absorption and thereby not only conserve refrigeration, but insure maintenance of the proper temperature throughout the system.

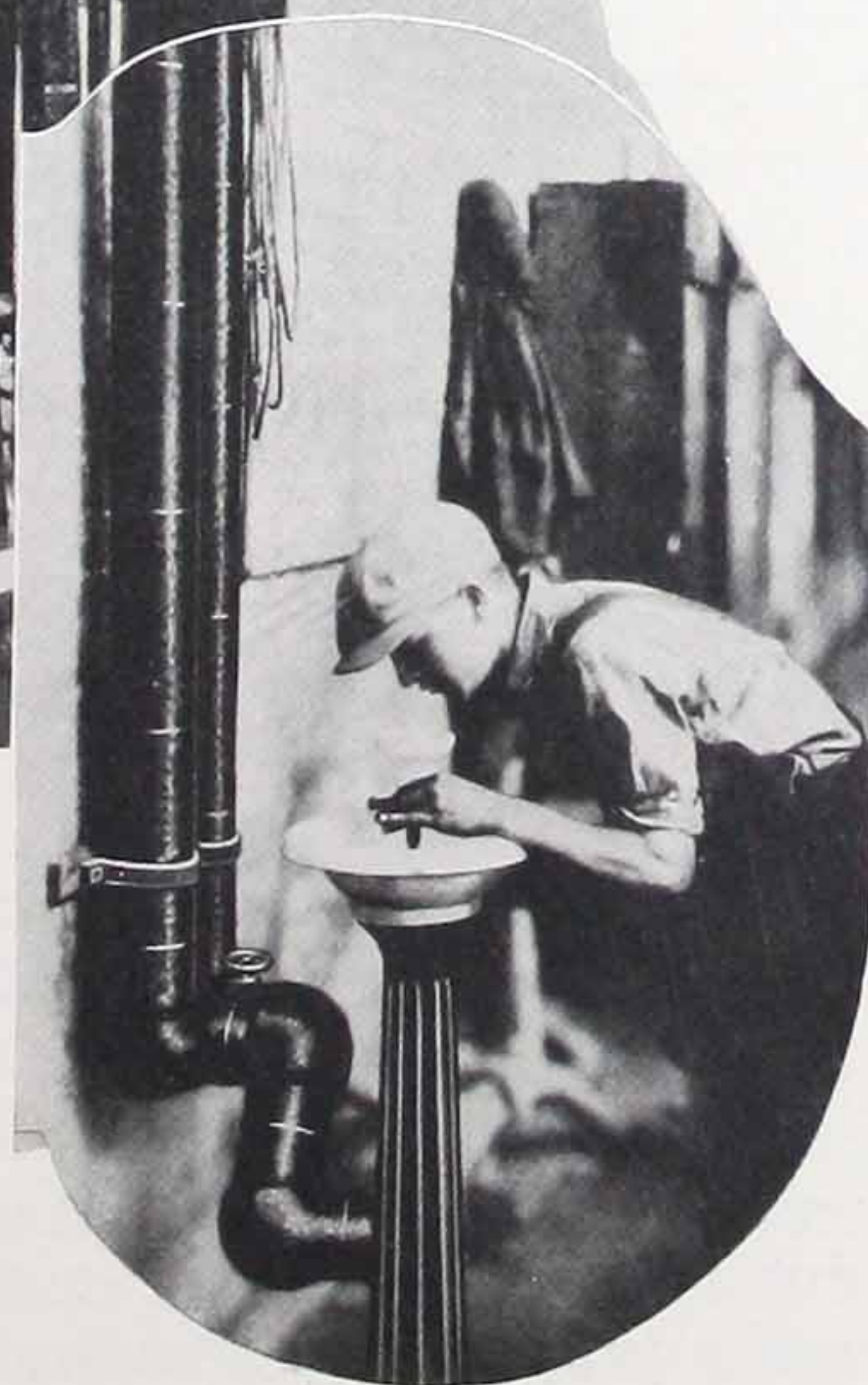
As a result, an ample supply of water was at all times available and easily accessible to all employees at a temperature which varied

no more than 2 or 3 degrees from 50° F. The total cost including all operating and maintenance expense, interest and depreciation was only \$1186.00 a year, a clear saving of \$614.00, or 34%.

Also from the Pacific Mills, Hampton Mills Department, Columbia, S. C.:



Distributing lines and tank, Nonpareil Cork covered, in the plant of the Proximity Manufacturing Company, Greensboro, N. C.



A good example of the shop drinking outlet. Note the "loop" which insures freshly circulated water right at the fountain. H. & B. American Machine Company, Pawtucket, R. I.

This mill formerly piped water to tanks in which ice was placed for cooling. Ice and labor were a considerable item of expense, and the system was most unsatisfactory. Ice deliveries were frequently late so that no water fit for drinking was available for some time after the mill started. On hot days the ice gave out before quitting time. At times the water was too cold; at others, so warm that it would not be used.

The company installed a refrigerated system in 4 mills, using 38 fountains to supply 1600 operatives. All lines were covered with Nonpareil Cork Covering and the water at the fountains was easily kept under 50° F.

The new system cost to operate, including all items, a half a cent a day per employee or \$2671.00 a year, as compared with the former cost for water, ice and labor of \$4353.00, a saving of \$1682.00 or 39%. The general superintendent states that while the monetary saving is of course important, the greatest benefit is in the effect on the operatives and the unquestionable improvement in their health and good will toward the company.

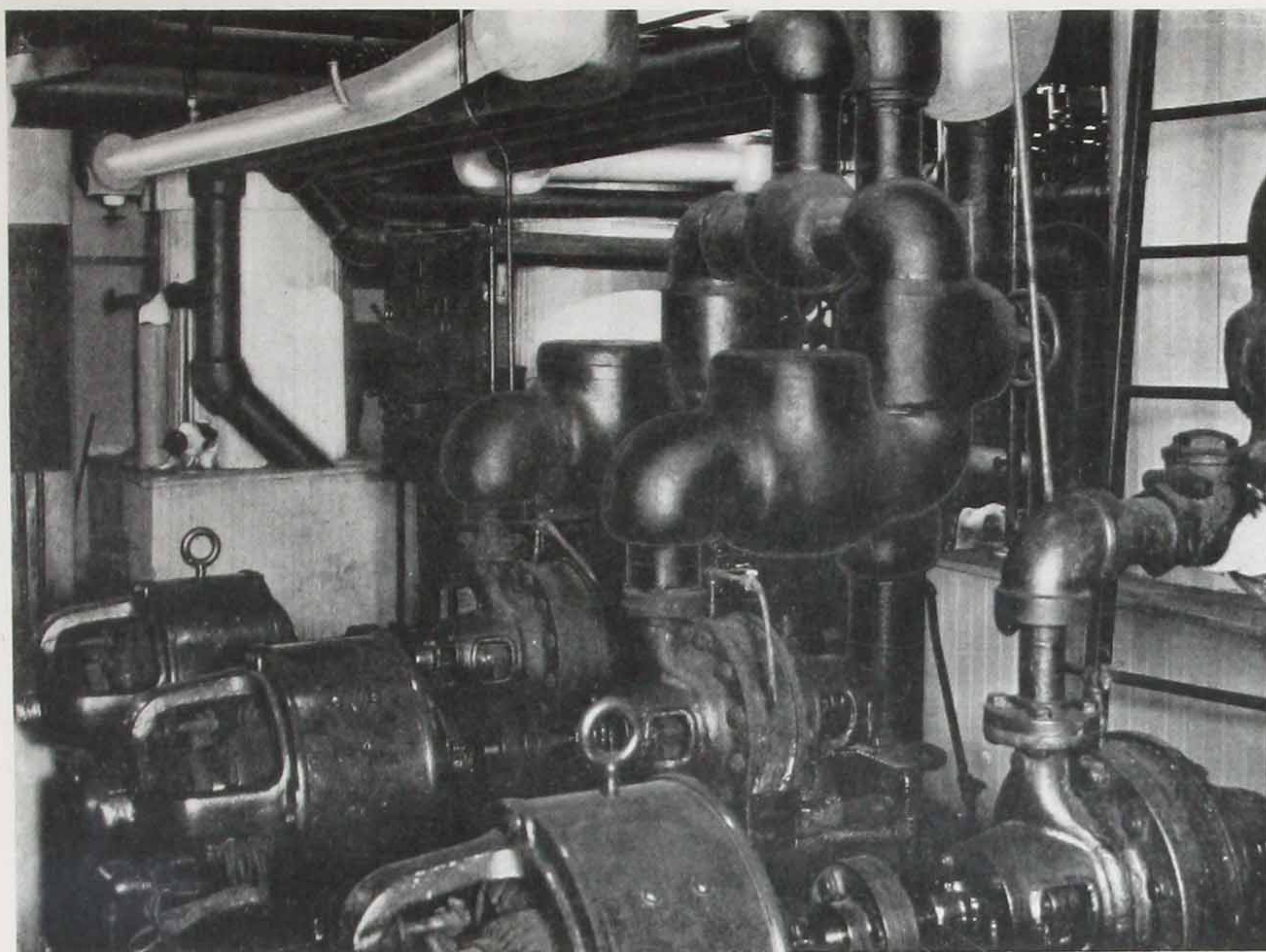
Copies of the full survey reports will be supplied on request.

The Purpose of Insulation

Before discussing different types of systems and their accessories, it is well at this point to give some consideration to the subject of insulation—a factor so essential to efficient and economical operation that it may, figuratively but accurately, be described as the foundation upon which the whole system stands. Upon the constant heat-retarding properties of the insulation for the pipe lines and equipment depend all the calculations for volume, velocity and refrigeration, which in turn determine the sizes of lines, pumps, tanks and refrigerating machinery. Study the calculations in the typical example given on page 36, and note how every element goes back ultimately to the heat absorption of the line and apparatus and, hence, is determined by the efficiency of the insulation.

In any layout, the greatest single factor in determining the refrigeration load is the line loss, which is always much more than the loss in water consumed, commonly referred to as the load. The longer the lines and the higher the temperatures of the rooms or buildings through which they run, the more important this factor becomes. Obviously it is in the interest of economy in both installation and operation that this line absorption of heat should be kept as low as is practically possible. The amount of refrigeration for cooling the makeup water depends on factors largely beyond control, that is on the temperature of the supply water and the amount taken from the lines, consumed and wasted. But the remainder, approximately half and often much more, is subject to control to a certain extent. It is the function of the insulation to protect the lines and equipment from heat and so to reduce the absorption to the practicable minimum.





*Notice the adaptability of Nonpareil Cork Fitting Covers on the pump connections.
This is a circulating equipment of the William Penn Hotel,
Pittsburgh, Pa.*

Another function of the insulation, very closely related to the one just mentioned and equally important, is to insure the maintenance, within a few degrees, of the entering temperature of the water, so that the temperature at the fountains or outlets may always be palatable. Since this is one of the principal reasons for the refrigerated system, it is clear that adequate insulation is of the first importance.

These facts are sometimes overlooked in designing a system of drinking water supply, the tendency being to emphasize the mechanical features and relegate insulation to the position of a minor detail. Wherever this is done, the system invariably fails to give satisfactory results. Either the temperature rise is such that the water is too warm at the outlet; or so much refrigeration is required to keep it cool that operating expenses are disproportionately high; or the lines sweat and cause considerable damage, especially when enclosed between walls or floors, or when run where drip may damage goods in manufacture or storage.

Furthermore, it is essential when figuring the requirements for water and refrigeration to know exactly what the heat absorption will be, not only when new, but throughout the life of the plant. The insulation must be of known quality, allowing the minimum absorption of heat. It must be so uniform in thickness, density, and heat-retarding value that its heat transmission is a constant factor. And it must be made of a non-fibrous, non-capillary material which will retain its structure and properties indefinitely, and not be subject

to progressive deterioration by moisture drawn into it from any chance point of contact. Only with such insulation can the system be designed and the requirements calculated in the utmost confidence that it will work out in service exactly as planned.

Throughout all calculations in this book, the insulation is assumed to be Nonpareil Cork Covering and Fitting Covers of Ice Water Thickness for the lines and Nonpareil Cork Lagging for tanks and other equipment. It is sufficient here to state that Nonpareil Cork Covering is the insulation generally recognized by refrigerating engineers as the standard for all low-temperature lines. A complete description of this material, its qualifications for this service and details of its use are given later in this book. (See page 28).

Types of Drinking Water Systems

Though differing somewhat in detail, the general design of a drinking water system is very much the same for a mill, a department store, a hotel, or an office building. The basic elements can best be understood by taking a simple and typical mill building layout such as shown in Figure I.

The essential elements are few and simple: an adequate supply of pure water, pumping equipment, tank for cooling the water, refrigerating machine, distributing lines, outlets, and insulation. In a word, apparatus to cool water to a desired temperature and to pump it to where it is used and back again, with insulation to maintain the temperature throughout the circuit.

For any layout, it should be borne in mind that, generally speaking, a number of short circuits are more satisfactory than one extremely long one. (By "extremely long" is meant a run of more than 2000 feet. Single circuits of 5000 feet are in successful operation, but on the whole, the shorter runs are better).

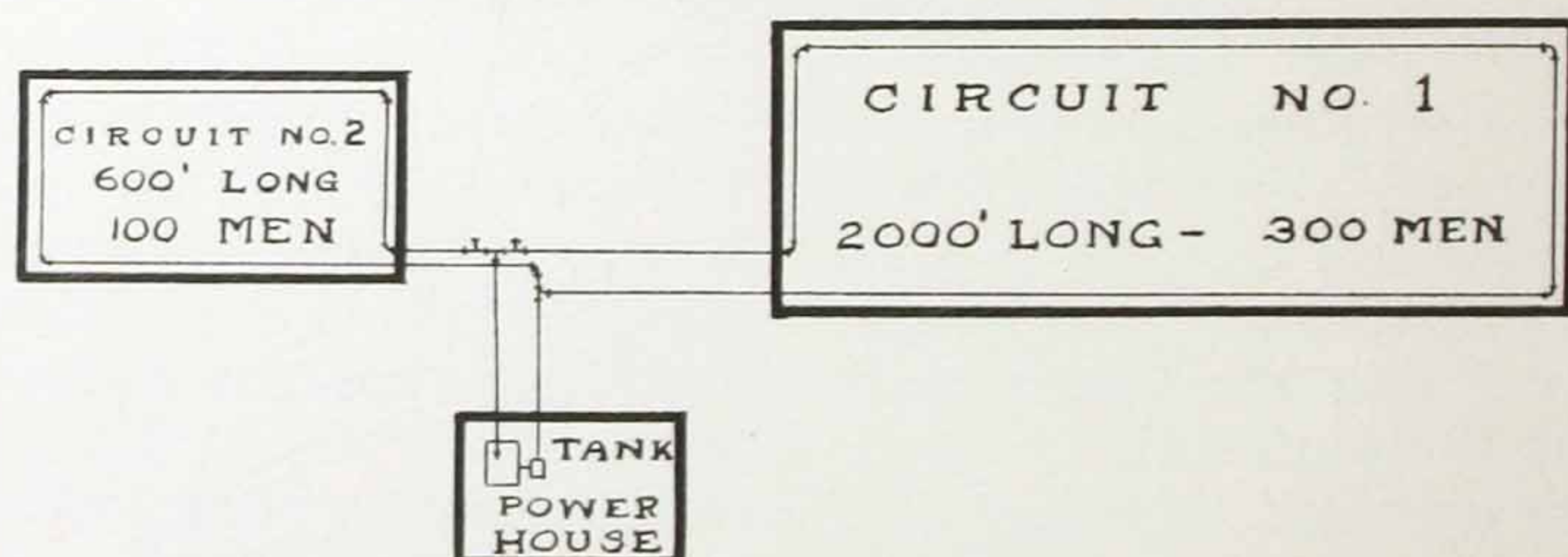
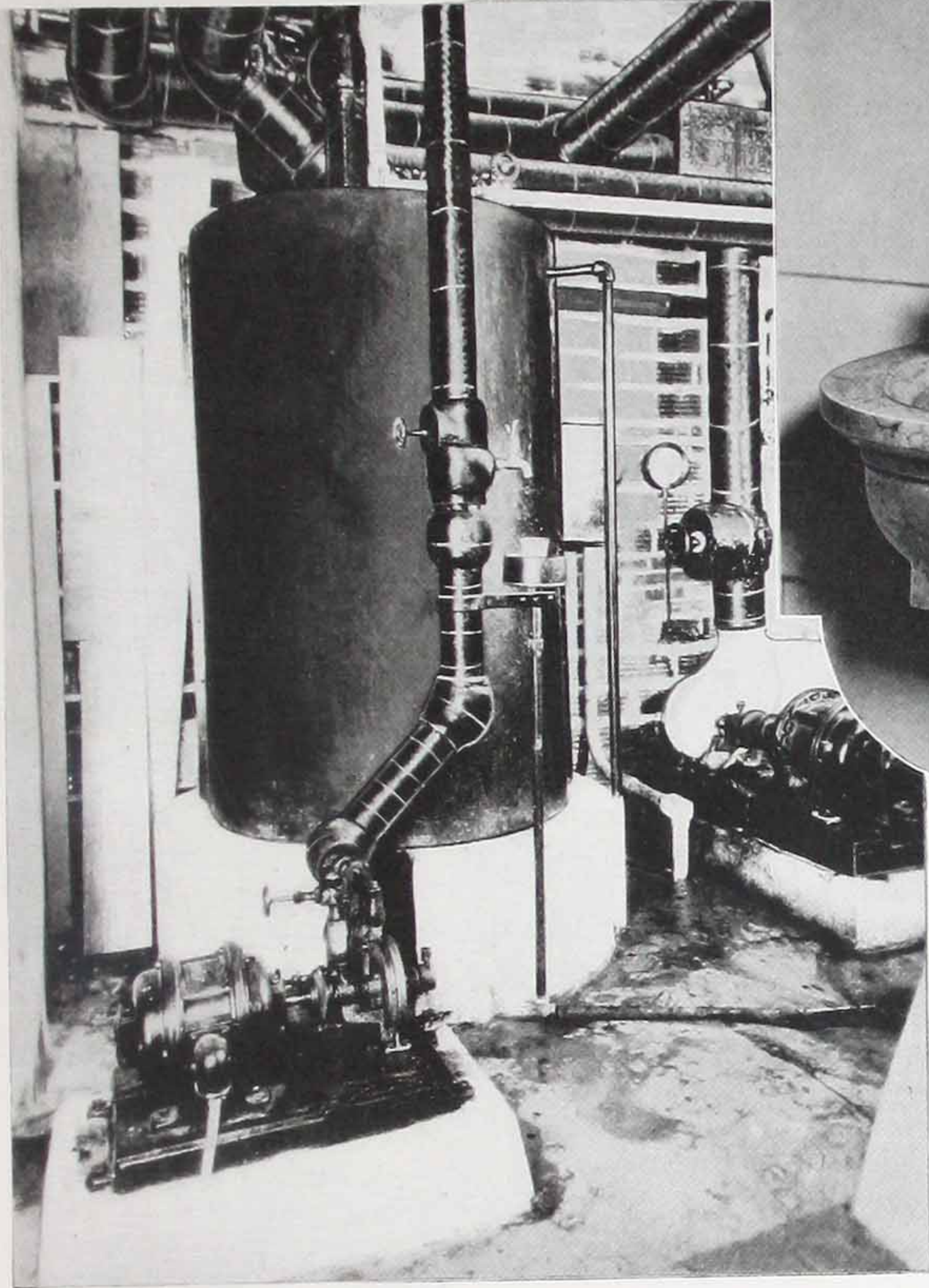


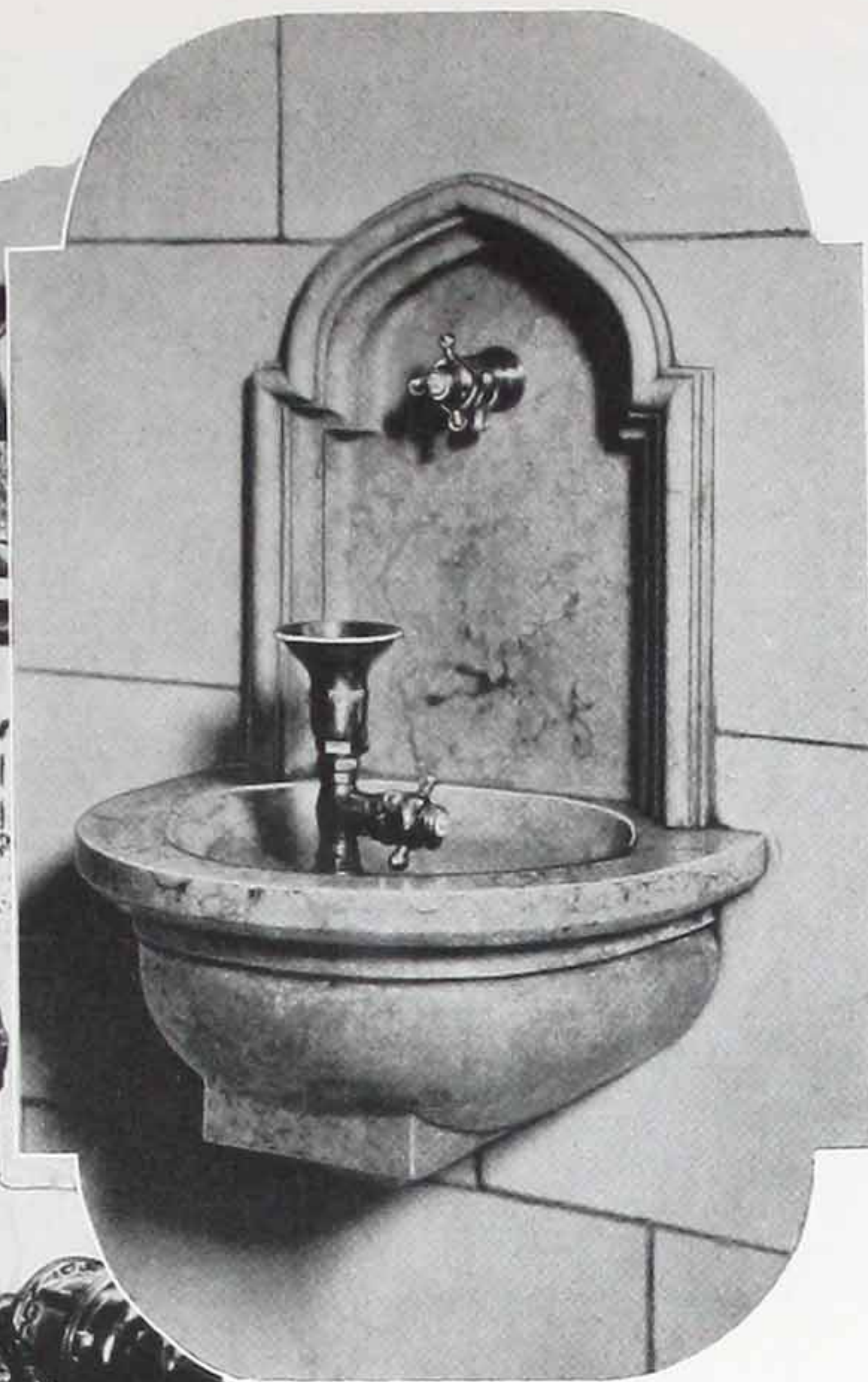
Fig. I

This plant consists of two main buildings, single story, with the power plant located approximately between them. One building requires a circuit of 2000 feet to supply 300 men; the other, a 600 foot circuit for 100 men. The main supply from the tank to the branches is 100 feet in length.

The run of the circuits and the number and location of the fountains are, of course, determined by the local requirements and general plan of the rooms to be served. The tanks, refrigerating equipment and pump are located in the power house.



*The Plaza (apartment hotel), Houston, Texas,
has Nonpareil Cork Covering throughout
on the drinking water system*



*A good type of
wall outlet. One
of the corridor
fountains in the
Union Trust
Building,
Pittsburgh, Pa.*

This, of course, is a very simple layout, but typical nevertheless, for almost all low buildings can be adequately served with a plan no more intricate than this. Sometimes there are complications due to peculiarities of local conditions, but these are usually of such a nature that they cannot be covered in a general description such as this book.

For Tall Buildings

Tall buildings present a somewhat different problem. The basic design is the same, but the details require special treatment. This is because a considerable part of the circuits are risers, and the gravity head and the possibility of high friction head increase the pumping load and require careful consideration of safe working pressures for pipes and fittings.

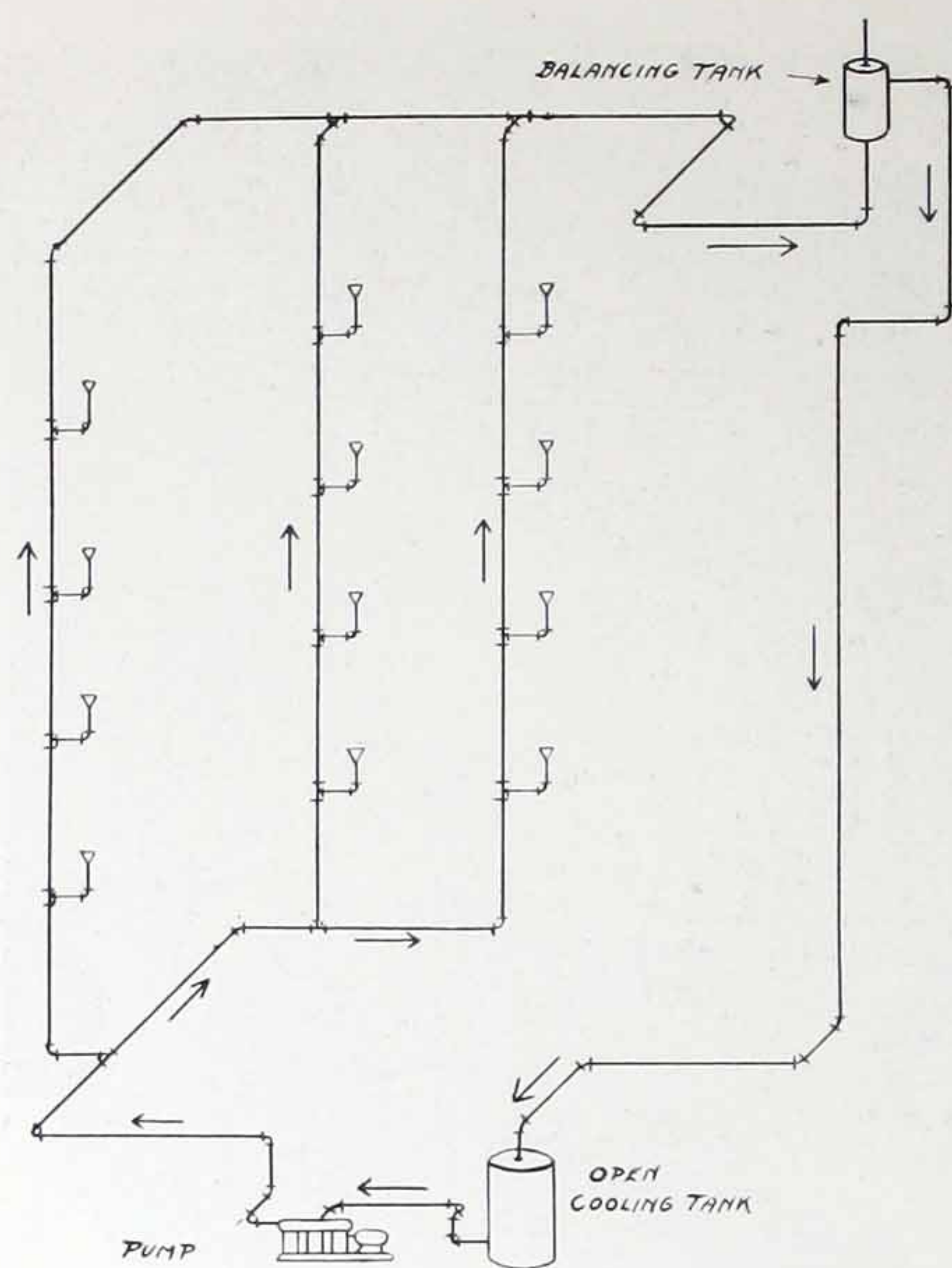


Fig. II

Figure II illustrates a system much used in high buildings. Water is pumped through a basement main into a system of risers which supply the fountains. The risers connect with the return main at the top of the system, usually in the attic, the return water entering the bottom of a surge, or overflow, tank (sometimes called a balancing tank) located at the high point. The return main takes off at the overflow connection near the top of the tank and carries the water back to the cooling tank in the basement.

This system has the advantage of simplicity of design and of positive circulation. Its one

disadvantage is the comparatively high cost of power for pumping.

Figure III, illustrates a system which makes use of the weight of the return water to counterbalance the weight of water in the risers. The principal work of the pump is to overcome the friction head. This system requires a well-made, closed-type cooling tank strong enough to withstand the pressure of the system with a reasonable factor of safety. Venting is accomplished through a balancing or surge tank with an emergency overflow as shown in Figure III.

An automatic diaphragm valve releases any air that gets into the system. There is an automatic cut-off at this valve which operates in case water should rise to it, passing the water through the overflow pipe into the house tank.

The balanced system uses a very small pump and the power cost is very low. This advantage is offset to some extent by the higher cost of the closed-type cooling tank.

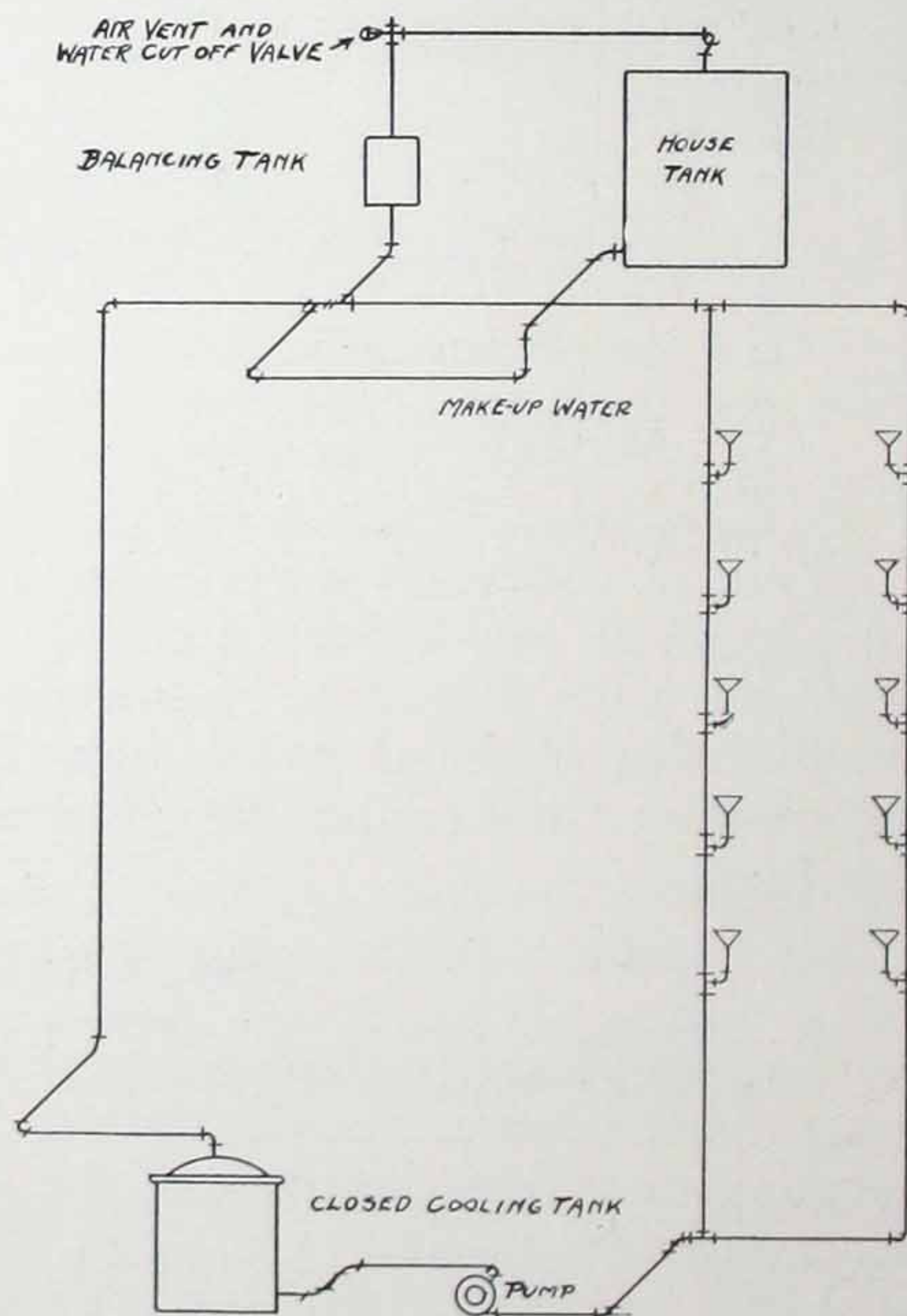
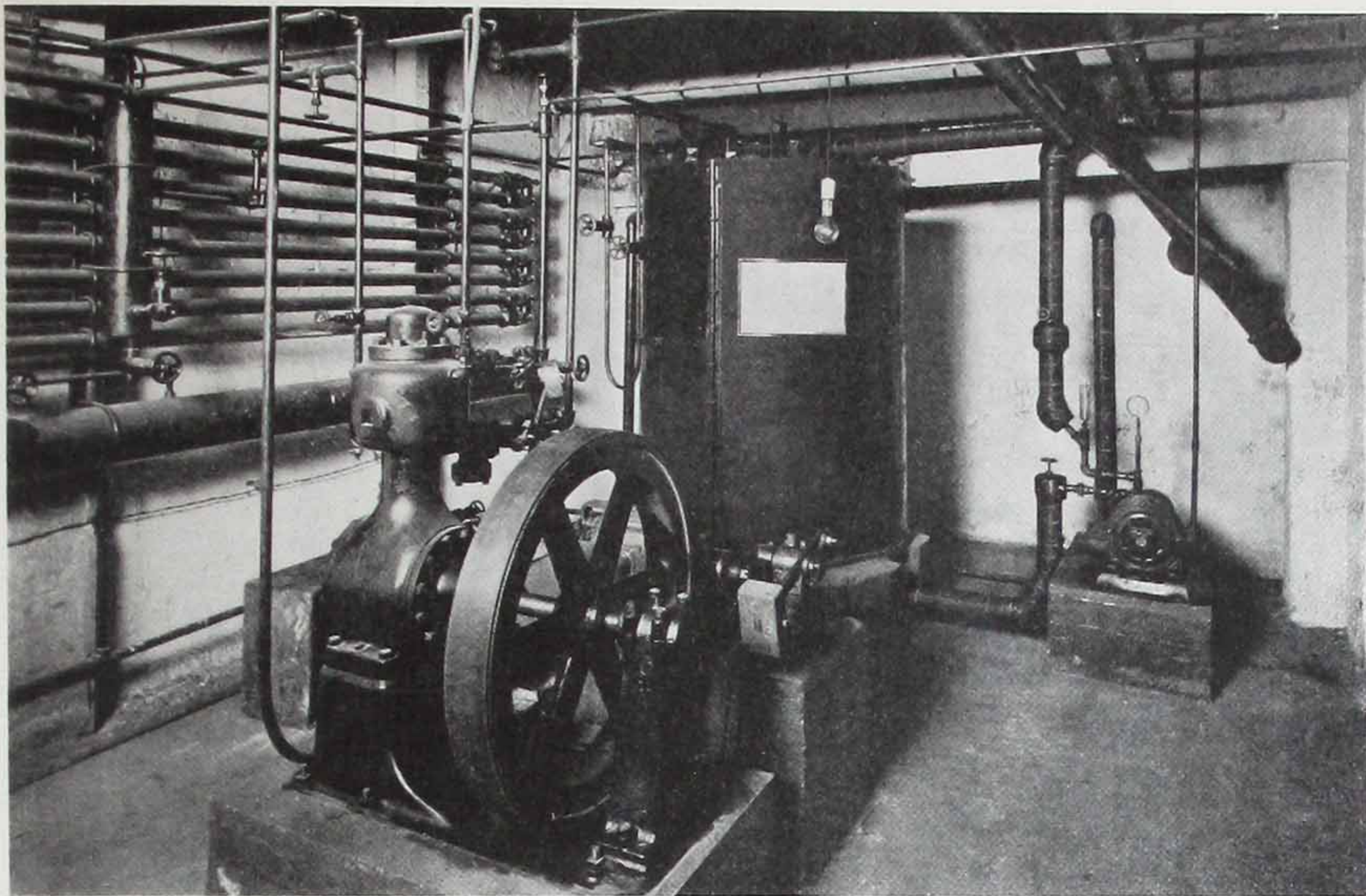


Fig. III



*The entire equipment for cooling and circulating occupies very little space.
Clinton Building, Tulsa, Okla.*

Discussion of Accessories

PUMPS—When specifying pumps for drinking water systems, it is necessary only to know the gallons per minute needed, the suction, head, the combined gravity and friction heads, and the kind of power available.

It is important to keep in mind that a smooth, non-pulsating flow is essential at the fountains or outlets. This can be assured by using either multi-cylinder piston pumps or single or multi-stage rotary or centrifugal pumps.

The relative merits of piston, rotary, and centrifugal pumps is the subject of much difference of opinion. Many engineers favor displacement pumps because of the positive pressure developed. Both centrifugal and rotary pumps have the advantage of affording a nonpulsating stream.

Provision is frequently made for duplicate pumps, connected in parallel, particularly where a shutdown may be a serious inconvenience.

COOLING TANKS—The cooling of drinking water is accomplished in tanks located close to the refrigerating machine and water supply. These tanks contain submerged coils for the circulation of the refrigerant, brine or expanding gas, (ammonia, carbon dioxide, sulphur dioxide, etc.). The most commonly used cooling tank is of galvanized steel, cylindrical or rectangular. The pump suction is taken from near the bottom and the return water enters at the top through a removable or hinged cover. This type is known as an "open" tank.



The convenience and cleanliness of circulated drinking water for factories are well illustrated in this view of the shops of the General Electric Company, Schenectady, N. Y.

The balanced pressure system requires a "closed" tank. This is built of steel with at least one removable flanged end. It must be strong enough to withstand the highest pressure developed in the system. Closed tanks may contain submerged coils, or they may be constructed on the shell and tube principle.

The sizes of tanks are determined by the size of the coils necessary for adequate cooling effect and will be specified by the refrigeration machine contractor.

Either type of tank must be well insulated on top, sides and bottom with two inches of Nonpareil Cork Lagging. The details of applying the insulation will be found on page 35.

When large quantities of water are used, a popular method of cooling is by means of the Baudelot cooler. This consists of several banks of coils containing the refrigerant, over which the water runs into a shallow open tank. Coils and tank are both located in a well-insulated room. While many engineers regard the Baudelot cooler as the most efficient, others prefer the shell and tube type for cooling large volumes of water.

BALANCING TANKS—The diagrams for tall building pipe circuits, Figures II and III, show a balancing tank at the high point. The usual connection takes the attic main into the bottom of the tank and the common return from between the middle and the top of the tank. It is good practice to provide an emergency overflow at a point slightly above the return to take care of any possible stoppage in the return. Venting should be provided by an open pipe.

It is common practice in high buildings to supply the makeup water (replacement of water used at the outlets) through the balancing tank. The usual method is to pipe water from the house tank by gravity to the balancing tank, maintaining a constant level by means

of a float valve. Such arrangement makes it possible to supply water over any period when, for one reason or another, the circulating system may be shut down. The water thus supplied is not, of course, either circulated or refrigerated, but it will suffice in an emergency.

Balancing tanks, like all other parts of the circulating system, should be thoroughly insulated. Otherwise, there will be a considerable rise in the temperature of the water, and the tanks will sweat and the drip cause damage below.

STERILIZERS AND FILTERS—Naturally, one of the first precautions to be taken is to ascertain the purity of the water supply. Usually it is entirely satisfactory, but if not, some method of sterilization should be used.

City or well water which is satisfactory as to bacteria content may be muddy or cloudy and consequently not attractive or inviting for drinking. Where such a condition exists or may exist, suitable filters should be provided. Filters are of many types, using sand, charcoal, fabrics, or other materials to remove matter in suspension. Their function is simply that of clarifying the water and their comparative merits can best be demonstrated by their manufacturers.

OUTLETS—Outlets are of two general types: (a) the spring faucet, used mostly in hotels as a part of the lavatory equipment, and (b) the fountain either as a wall or pedestal fixture. The fountain is greatly to be preferred where a number of persons use the outlet, otherwise individual cups are required to comply with the laws of most states.

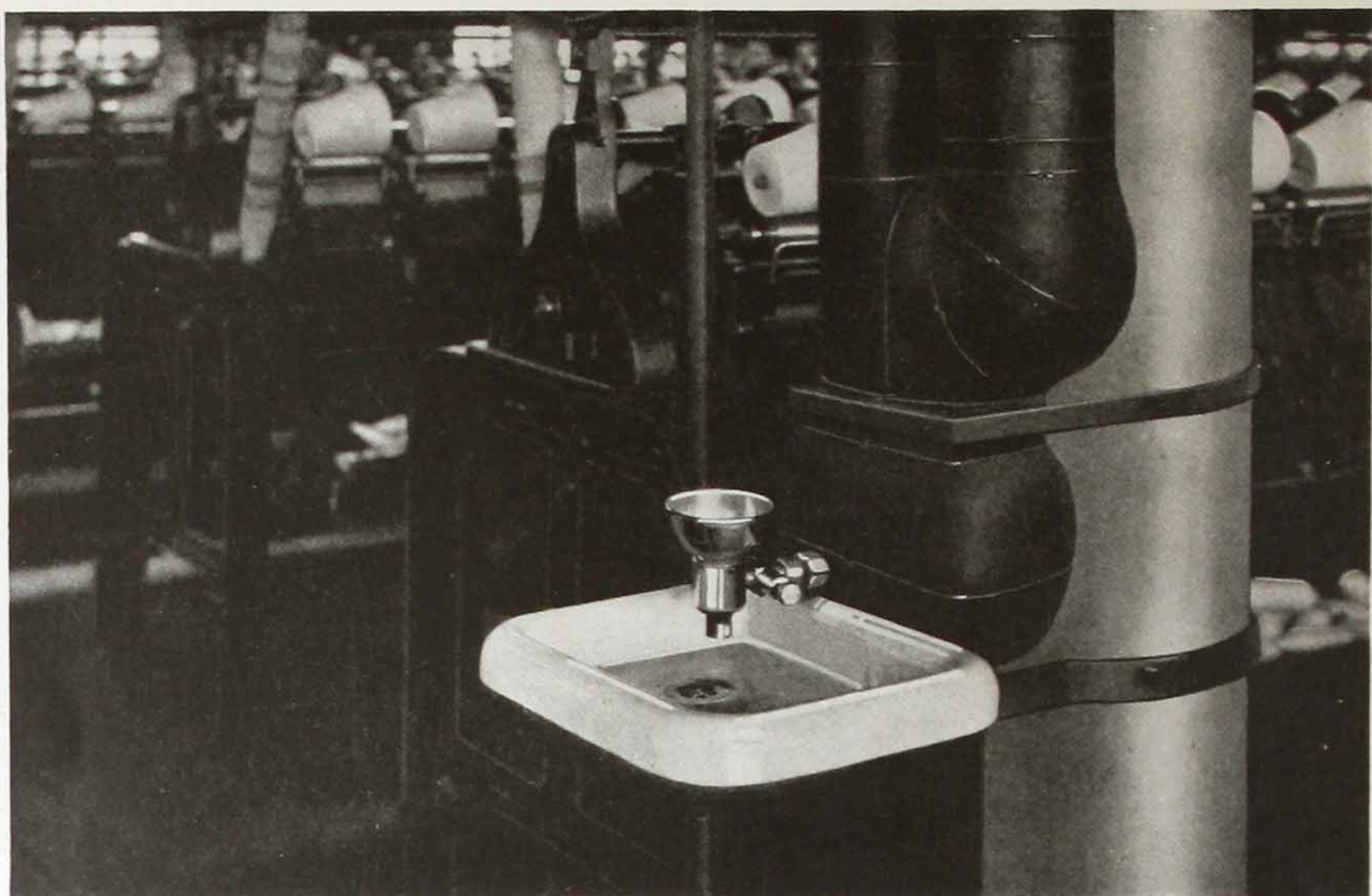
Pedestal fountains are generally used in industrial plants and in other large rooms where more central locations are preferable to walls. In schools, hospitals, office buildings and corridors, the wall type is perhaps more suitable. In any case, the fountain should have a well-designed orifice or group of orifices so as to throw a heavy and steady jet in such position as to make drinking easy and comfortable. The orifice should be so shaped, protected, or located that it cannot come in contact with the lips, or allow the water to fall back into the fresh water supply. Needless to say, a fountain should be easily cleanable and attractive and sanitary in appearance.

There are many types of such faucets and fountains on the market and the selection is largely one of taste and cost.

PIPING—All drinking water pipes and fittings should be galvanized steel or wrought iron, with smooth interior walls. Fittings should preferably be long sweep so as to reduce the friction head as much as possible. In tall buildings, the pressure and gravity head are frequently such as to require extra-heavy pipe and fittings, at least in the lower part of the system.

REFRIGERATION—There are several distinct types of refrigerating apparatus, such as the compression system, the absorption system, etc., and many different machines and systems of each type, using various refrigerants, ammonia, carbon dioxide, sulphur dioxide, etc. Each has its merits and it is clearly outside the province of this book





Fresh, cold water is instantly available from this convenient mill outlet. The lines at the fountain, as throughout the system, are insulated with Nonpareil Cork Covering. Durham Hosiery Company, Durham, N. C.

to attempt any distinction among them. The type and make of the refrigerating machinery must be left to the mechanical engineer in charge of designing the system.

Details of Installation

POWER EQUIPMENT—Pumps, cooling tank, refrigerating machinery, and filters should be located as centrally as possible in order to keep the various circuits short, and preferably in or near the building power plant to economize on power for operation. Such arrangement permits the plant engineer to take over the operation of the drinking water system without extra help.

PIPE LINES—Keeping in mind that the lines should be looped at the fountains to avoid dead ends, care should be taken to run all lines as straight as the layout will permit with as few bends and offsets as possible. This is for the purpose of keeping down the friction and thereby the cost of power for pumping. The friction tables on pages 44 and 45 show the increased head due to friction. All lines should be well supported so as to prevent sagging.

DEAD ENDS—Piping should be so arranged as to avoid all dead ends at the fountains. A dead line, that is a line not in active circulation, at a fountain means a pipeful of warm water to be run off before the cold water comes, involving a waste of both water and time. The water must circulate continuously past the fountain connection

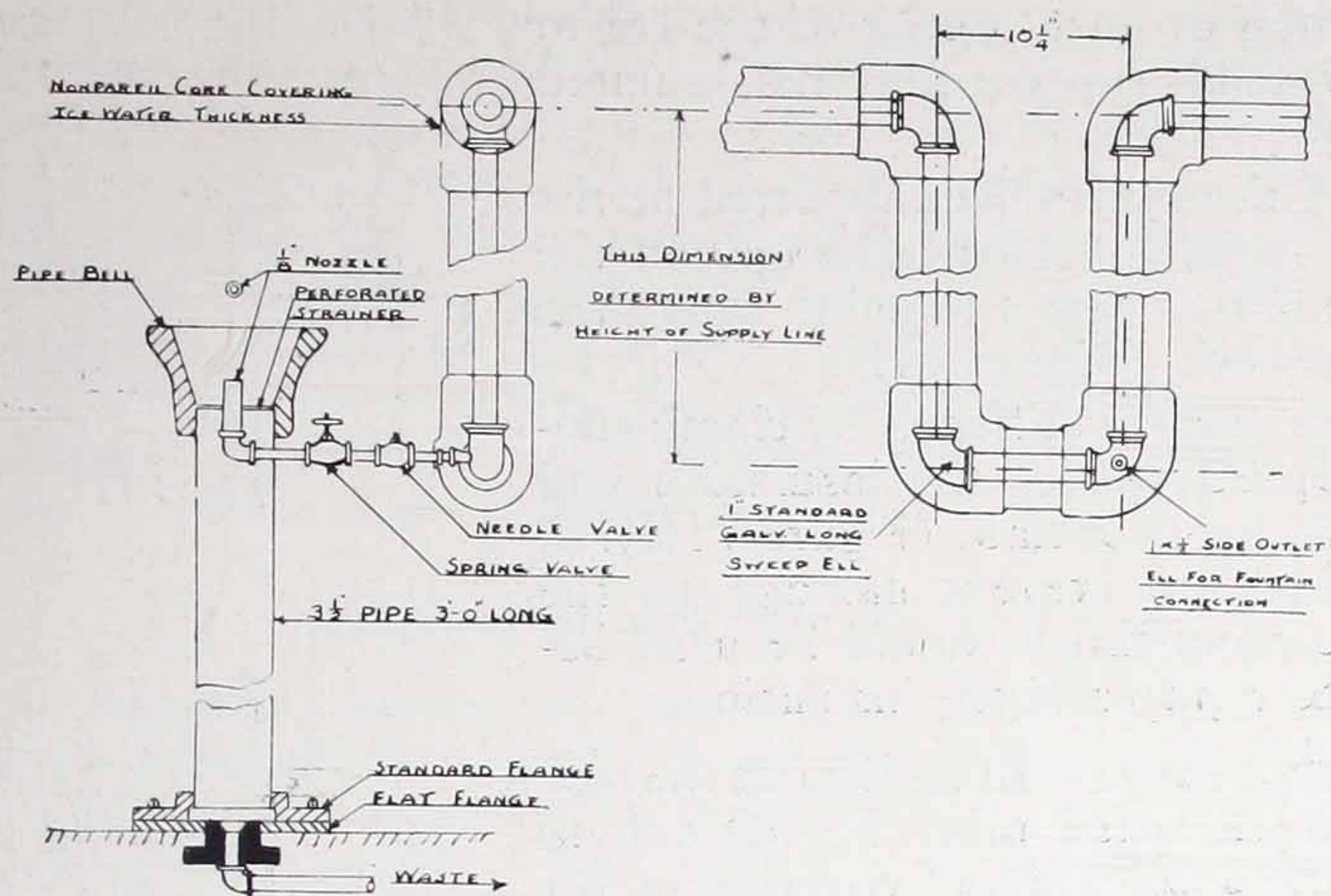


Fig. IV

so that the drinker may get fresh, cold water almost instantly. A good arrangement to insure this condition is shown in Figure IV.

PIPE SUPPORTS—All refrigerated lines should be supported on hangers *outside the insulation*. A through-metal connection from the outside air to the line breaks the insulation and allows a certain amount of refrigeration loss. Moreover, and of even greater importance, a hanger in contact with the pipe will become cold enough to

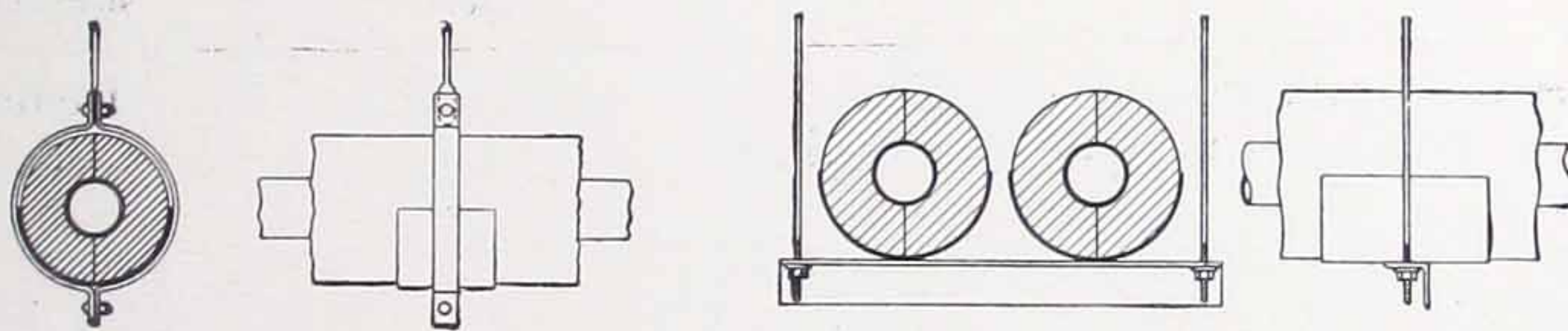


Fig. V

sweat, and the moisture will drip down and work under the insulation, a condition very detrimental to its efficiency and life in service. Figure V shows two types of outside hanger. The lines may be supported temporarily while the insulation is being applied on blocks of wood or other material set in the hanger. Many hanger rods are threaded for adjustment after the insulation is in place.

RISER SUPPORTS—The risers in hotels, apartments, hospitals, etc., should be so supported that the insulation can be applied continuously with no through-metal connections such as clamp hangers or stiffeners.

Long risers of great weight are best supported by a pedestal elbow or long-sweep tee (Figure VI) at the point where the riser leaves the horizontal run and enters the pipe-chase. A support is run from

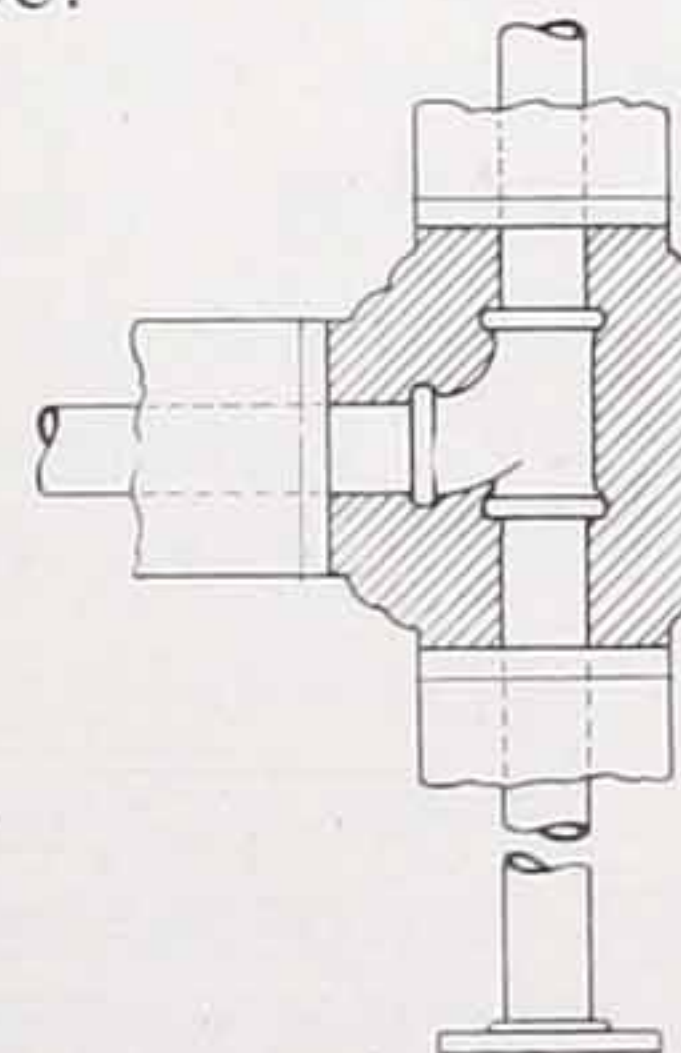


Fig. VI

the pedestal or lower outlet of the tee to the floor. This support may be insulated to prevent sweating.

Short risers may be supported at the base by means of a strap hanger on the horizontal run near the point where the riser takes off. (Figure VII).

Risers may be stiffened by clamp supports applied *outside* the insulation and resting on the floor slab. (Figure VIII). A metal shield to prevent damage to the moisture-proof finish should be used between the clamp and the insulation.

SPACING LINES—In laying out the pipe lines, ample space must be allowed to permit the application of covering of the proper thickness.

When using the following tables, bear in mind that the size of the fitting insulation has been taken into account, and that plenty of space has been left so that there will be room to apply Nonpareil Cork Fitting Covers on every fitting without cutting away any of the cork.

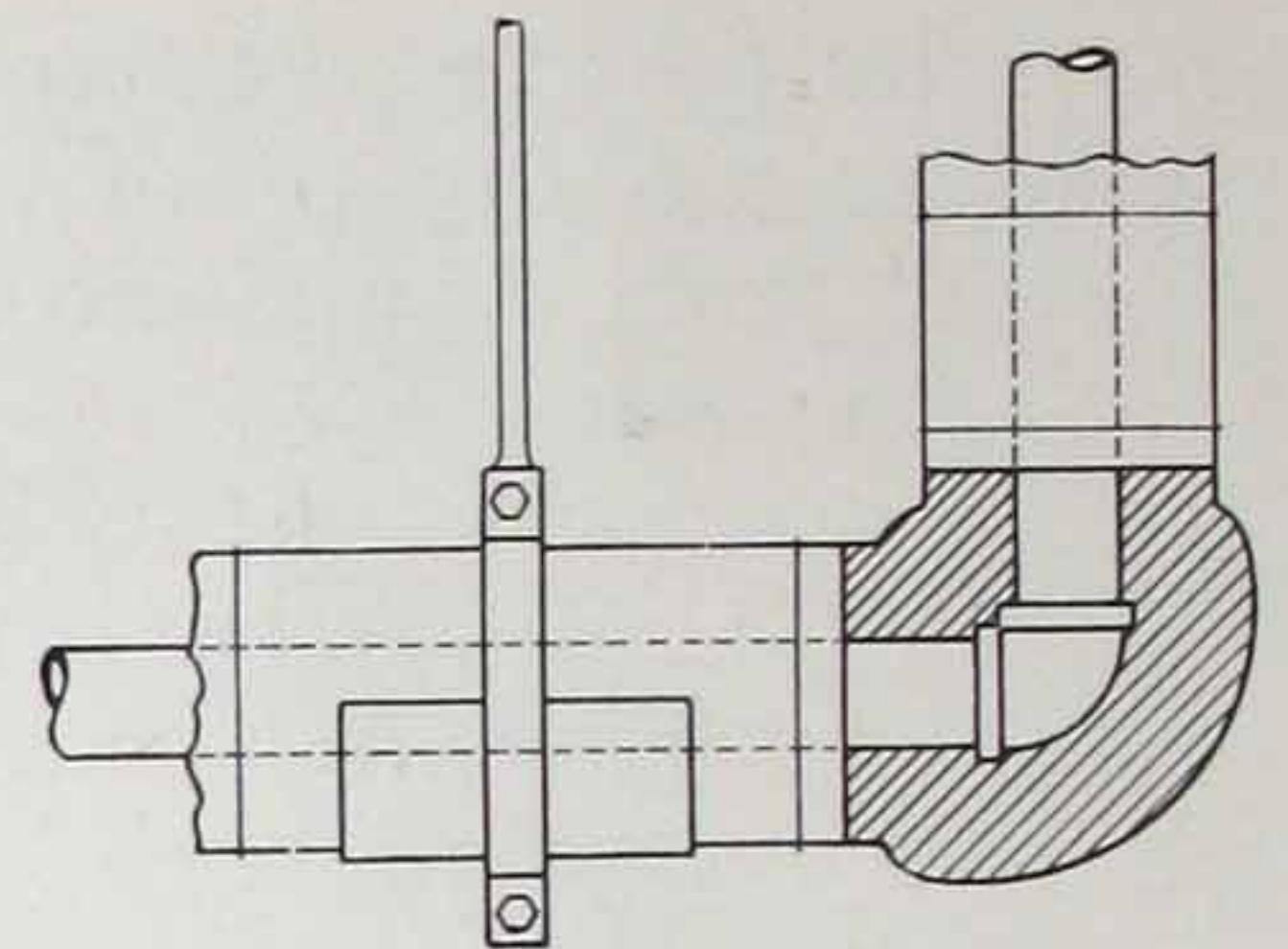


Fig. VII

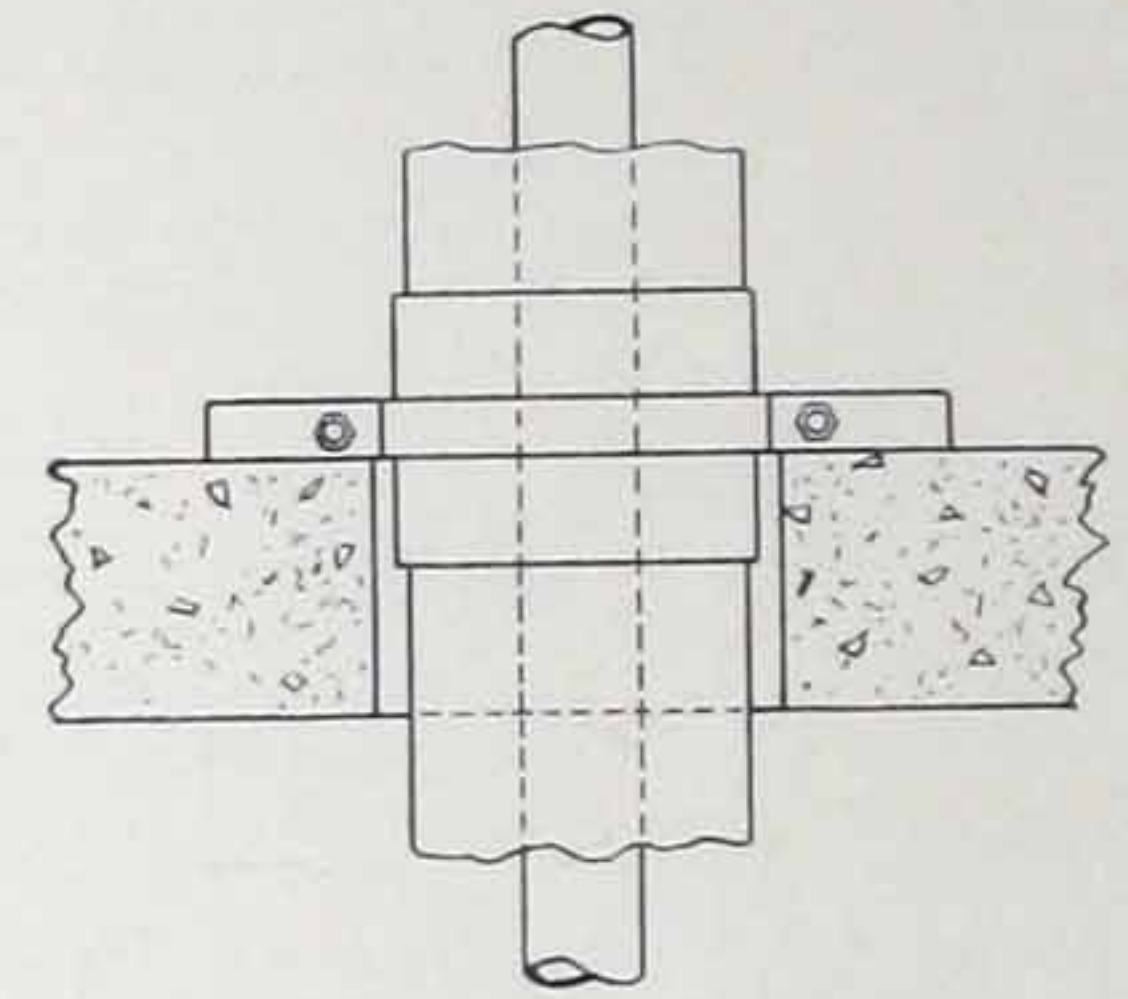


Fig. VIII

THICKNESS OF COVERING	Space Required between parallel pipes	Space Required between pipes and adjacent surfaces
ICE WATER THICKNESS—(Water Lines)	Inches	Inches
Screwed Fittings up to and including 6-inch.....	6	4
Screwed Fittings larger than 6-inch.....	10	5
Flanged Fittings.....	10	5
BRINE THICKNESS—(Refrigerating Lines)		
Screwed Fittings up to and including 6-inch.....	8	4
Screwed Fittings larger than 6-inch.....	14	8
Flanged Fittings.....	14	8

UNDERGROUND LINES—Drinking water lines laid underground should be run in well-drained tunnels, split-tile conduits, or concrete trenches. This permits of easy access for repairs, changes, and inspection.

OUTSIDE LINES—When drinking water or other refrigerated lines are run outdoors or exposed to weather, they must be protected by a roof jacket applied over the insulation. See Specification No. 3, on page 35.

INSULATION—The necessity for adequate insulation of all lines and low temperature apparatus has already been referred to (page 14), and is treated in more detail in a later section of this book. Detailed specifications will be found on pages 33 to 35.

FINISH—The regular finish on Nonpareil Cork Covering is a moisture and air-proof coating of a special asphaltic composition. Painted with Nonpareil Cork Covering paint, it is glossy black and makes a neat appearance. It is, however, sometimes desirable to have a different finish, where lines run, for example, through hospital corridors, hotel kitchens, stores, etc. In such cases, the lines may be wrapped with rosin-sized paper and a canvas jacket sewed on, and finished, if desired, with a glue size and lead and oil paint. Aluminum bronze paint may also be used, applied directly on the black finish without canvas or other preparation.

Engineering and Advisory Service

The historical outline on pages 6 and 7 conveys some idea of the long and varied experience of the Company's Engineering Department in the design and development of this modern system of drinking water supply. They have been in intimate touch with it from the time of its crude beginning and have been largely instrumental in working out its problems, in perfecting its details, and in devising means of meeting its many requirements under almost every conceivable condition, normal and abnormal.

The Company offers its services, without charge or obligation, together with the benefit of its experience and specialized knowledge of this subject in cooperation with building and plant engineers and architects. The Engineering Department will gladly make detailed surveys, calculate requirements and supply data for the proper design of a drinking water system in accordance with modern practice. The Company does not sell or install any part of the equipment excepting insulation.

All branch offices and representatives of this Company have engineers who are qualified to render this service, and to provide full information. It is well understood that the consideration of a refrigerated drinking water system requires a good deal of preliminary calculation, comparison with present methods, estimation of expected benefits, economies, etc. prior to a final decision and actual installation. It is for the purpose of supplying the data for such consideration that the Company's resources are made available to all who are interested.

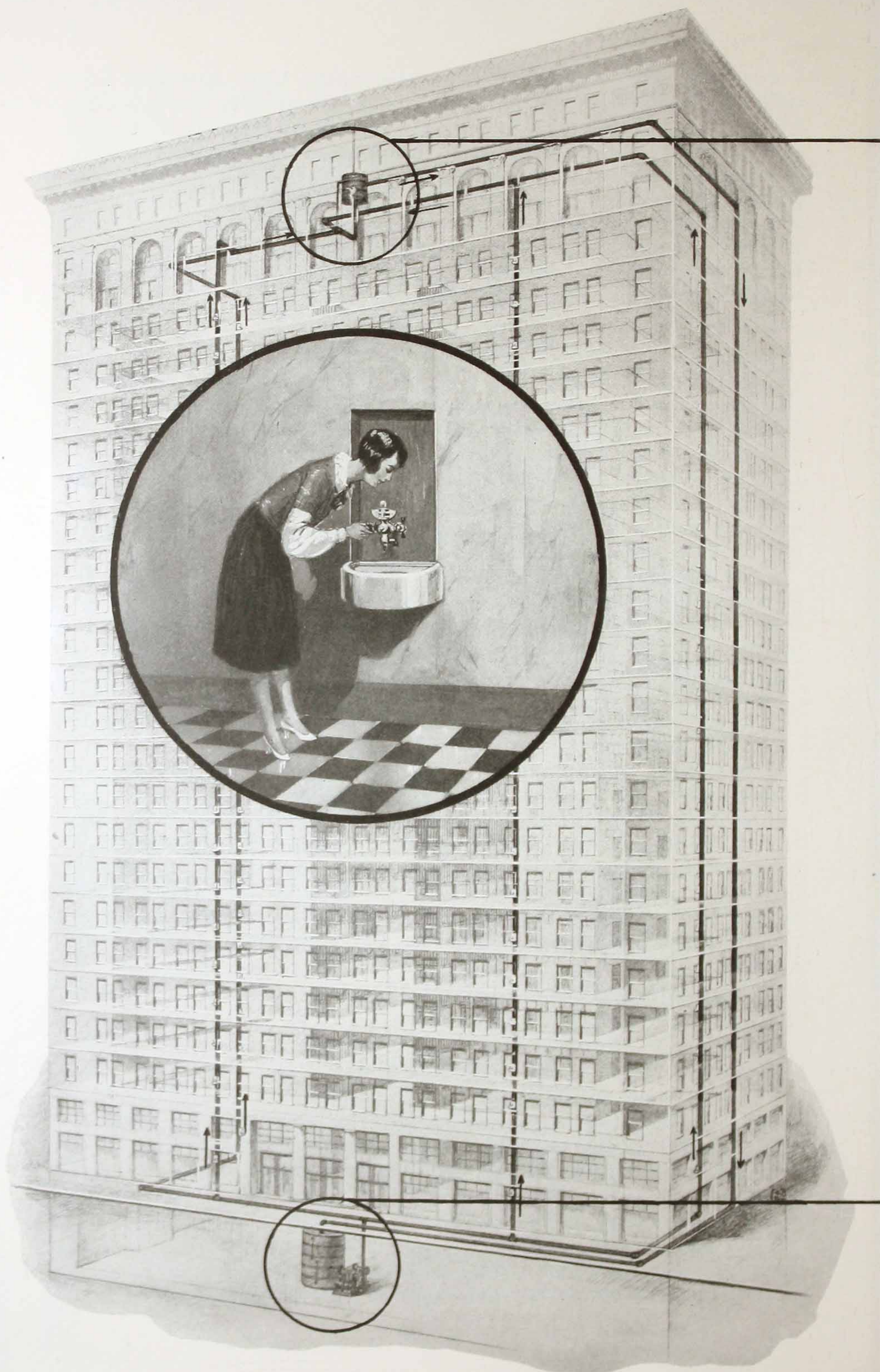
The general method for arriving at the requirements is shown in the typical calculations on pages 36 to 40.

The Insulation

The adequate insulation of all low-temperature lines and equipment is so essential to successful operation that it is deserving of quite detailed treatment. A drinking water system well designed and laid out mechanically may nevertheless prove unsatisfactory and expensive unless thoroughly protected against surrounding temperatures by an efficient insulation.

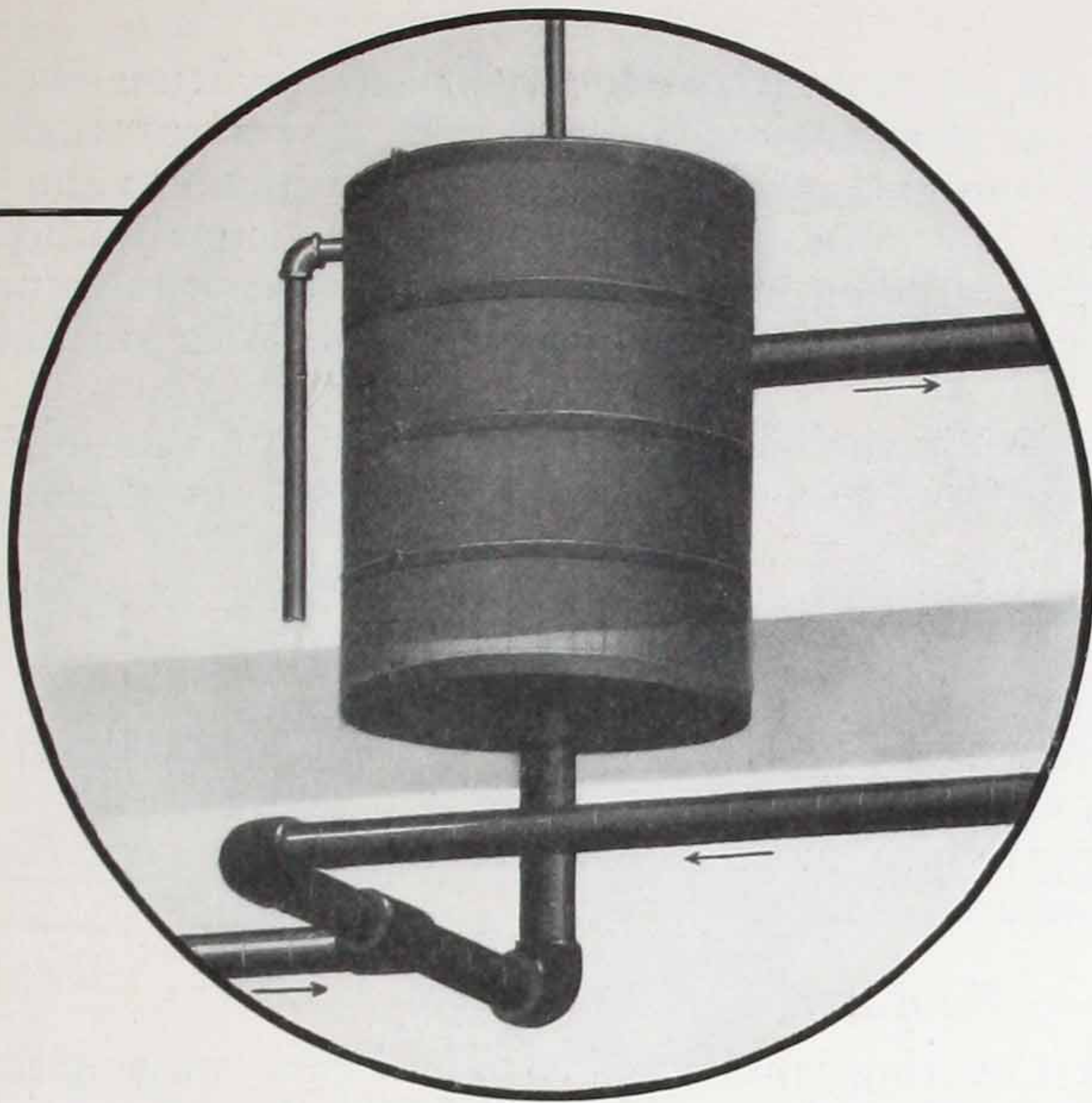
But efficiency is only one of the qualities essential to insulation. It must be *permanently* efficient, which means simply that it must be moisture-proof, for aside from accident and



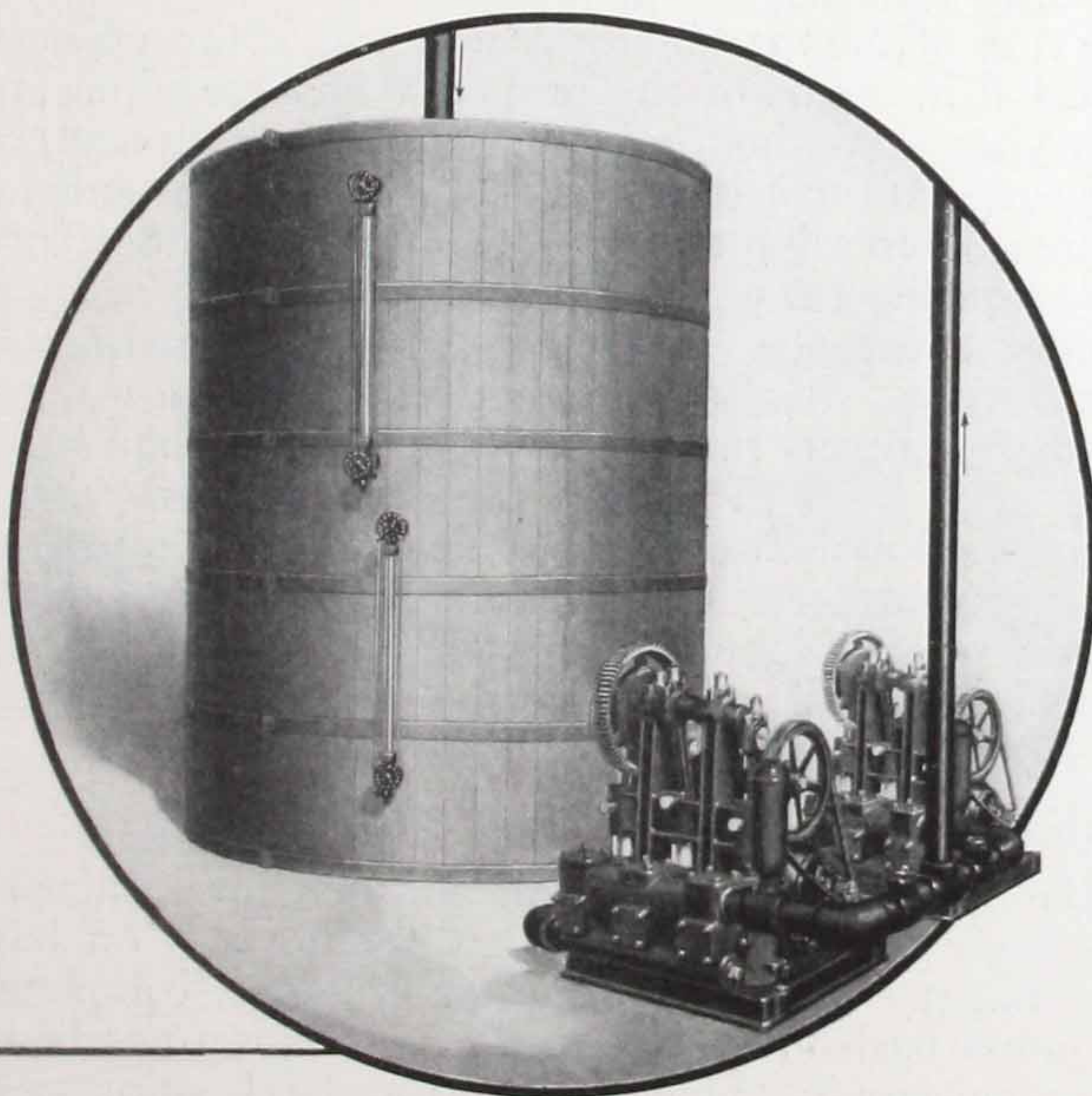


TYPICAL OFFICE BUILDING INSTALLATION C

Showing run of lines for corridor fountains, basement co



(a) Enlargement of balancing tank and connections at the high point of the system



(b) Enlargement of water cooling tank with pumps and connections. Duplicate pumps are used

abuse, moisture is the greatest menace to any low-temperature insulation. Water being an excellent *conductor* of heat, any absorption of moisture rapidly and progressively increases the conduction value of the insulation. Not only must the material itself be nonabsorbent, but it must be capable of being so applied that moisture or moisture-laden air cannot penetrate at the joints and so get between or under the covering.

It must be furnished in such form as to be easily applied on pipes, fittings, and other surfaces so as to fit tightly without air spaces or pockets.

It should be slow burning and of such nature that it will not smolder or carry fire from one point to another.

It should present a neat finished appearance.

It must be reasonable in cost of material and application and in upkeep, or maintenance, cost.

The one material which most completely meets these exacting requirements is Nonpareil Cork Covering.

Nonpareil Cork Covering

Nonpareil Cork Covering is made of cork and cork only—clean, dry granules of pure cork without any artificial binder. Cork is a mass of minute air cells, so small and so well sealed off from each other that there can be no circulation of air in or between them. In other words, cork is made up largely of entrapped air, and entrapped still air is the best heat insulation known except a vacuum, which is not practicable on a large scale.

In the manufacture of Nonpareil Cork Covering, clean granules of cork are compressed in molds of the proper shapes for pipes and fittings of different sizes, and then baked. The baking process, by driving off all moisture and volatile matter increases the proportion of cell content, thereby increasing the insulating value of the natural cork. The heat also liquefies the gum or resin in the cork. This gum, a natural waterproof substance, is the binder that cements the granules into a solid mass. It also spreads over the surface of the granules and effectually protects them from the entrance of moisture.

As the sections come from the molds they are finished with a heavy coating of air- and moisture-proof mineral rubber ironed on both inside and outside surfaces. Full details of the several thicknesses and shapes in which Nonpareil Cork Covering and Fitting Covers are made will be found in the section "Service Details" on page 32.

The Insulating Efficiency of Nonpareil Cork Covering

Thoroughly reliable values have been established for insulating efficiency by tests made on Nonpareil Cork Covering and on bare pipes. The latest and, it is believed, the most accurate (completed May, 1924) are summarized on the basis of transmission per lineal foot for the various pipe sizes in Tables No. I, II and III. Nonpareil Cork Covering effects an average saving of 85.6% of the refrigeration lost by the absorption of heat through uninsulated pipe and fitting surfaces.

Table No. I
NONPAREIL CORK COVERING
Ice Water Thickness

Pipe Size inches	Trans. in B. t. u. per lin. ft., per deg. F. dif. in temp. for		Pipe Size inches	Trans. in B. t. u. per lin. ft., per deg. F. dif. in temp. for	
	1 hour	24 hours		1 hour	24 hours
$\frac{1}{4}$	.101	2.42	$3\frac{1}{2}$	.292	7.00
$\frac{3}{8}$	.114	2.74	4	.311	7.46
$\frac{1}{2}$	.132	3.17	$4\frac{1}{2}$	.335	8.05
$\frac{3}{4}$	.140	3.37	5	.371	8.90
1	.152	3.64	6	.397	9.53
$1\frac{1}{4}$	.173	4.15	7	.458	11.00
$1\frac{1}{2}$	.187	4.50	8	.504	12.1
2	.216	5.20	9	.548	13.4
$2\frac{1}{2}$	.257	6.17	10	.571	13.7
3	.273	6.55	12	.75	18.0

Table No. II
NONPAREIL CORK COVERING
Brine Thickness

Pipe Size inches	Trans. in B. t. u. per lin. ft., per deg. F. dif. in temp. for		Pipe Size inches	Trans. in B. t. u. per lin. ft., per deg. F. dif. in temp. for	
	1 hour	24 hours		1 hour	24 hours
$\frac{1}{4}$	.088	2.12	4	.231	5.55
$\frac{3}{8}$	.098	2.36	$4\frac{1}{2}$	.219	5.26
$\frac{1}{2}$	.113	2.71	5	.25	6.05
$\frac{3}{4}$	.12	2.87	6	.285	6.85
1	.129	3.11	7	.32	7.68
$1\frac{1}{4}$	.135	3.22	8	.328	7.88
$1\frac{1}{2}$	.138	3.32	9	.339	8.15
2	.158	3.80	10	.376	9.02
$2\frac{1}{2}$	.175	4.21	12	.434	10.4
3	.187	4.49	14	.471	11.3
$3\frac{1}{2}$	.199	4.78	16	.525	12.6

Table No. III
BARE PIPE

Pipe Size inches	Trans. in B. t. u. per lin. ft., per deg. F. dif. in temp. for		Pipe Size inches	Trans. in B. t. u. per lin. ft., per deg. F. dif. in temp. for	
	1 hour	24 hours		1 hour	24 hours
$\frac{1}{4}$	.34	8.2	4	2.06	49.5
$\frac{3}{8}$	.406	9.75	$4\frac{1}{2}$	2.29	54.5
$\frac{1}{2}$	.485	11.6	5	2.49	59.8
$\frac{3}{4}$	.581	14.0	6	2.90	69.6
1	.698	16.7	7	3.33	79.6
$1\frac{1}{4}$	.856	20.5	8	3.74	89.7
$1\frac{1}{2}$	.960	23.0	9	4.16	100.
2	1.16	28.0	10	4.63	111.
$2\frac{1}{2}$	1.39	33.3	12	5.49	132.
3	1.66	40.0	14	5.88	141.
$3\frac{1}{2}$	1.86	44.6	16	6.75	162.

The Durability of Nonpareil Cork Covering

Unless pipe insulation is durable, its initial insulating efficiency, no matter how high, is of little value. Durability in cold pipe covering means just one thing—the ability to resist moisture. Now, it is almost impossible to waterproof any fibrous materials so as to overcome their tendency to take up moisture by capillary attraction. In spite of the efforts to render them impervious, sooner or later moisture will get into them. Even the most careful and exacting workmanship involving very high labor cost, cannot insure the application of felted coverings in such a way as to close up all openings and protect the absorbent material from contact with moisture.

Moisture acts in such insulators exactly as oil does in a lamp wick. Capillary attraction draws it along the fibres until the substance becomes more or less saturated throughout. As a result of the covering being permeated by moisture, which is a good conductor of heat, its capacity to retard heat is destroyed. This process may be quite slow and give little or no outward evidence of its existence until it has made considerable progress. But *efficiency begins to diminish as soon as absorption starts*, and the end is inevitable—the material ceases to be an insulator and becomes a conductor of heat.

Nonpareil Cork Covering possesses no capillary attraction. It is cellular in structure, not fibrous, and its minute air cells are impenetrable to moisture. Each granule of the cork becomes coated in the manufacturing process with the natural waterproof resin. The mineral-rubber finish is a further protection against moisture. In applying Nonpareil Covering, all joints are cemented with Nonpareil Waterproof Cement and smoothed with Nonpareil Seam Filler. Hence, the covering, properly installed and given a reasonable amount of attention, keeps dry and retains its original efficiency. There is no progressive deterioration in its insulating value or structural strength, and no reason why Nonpareil Cork Covering should not last as long as the pipes.

The durability of Nonpareil Cork Covering on cold lines is doubly assured by reason of the fact that the fittings can be insulated just as efficiently as the pipes. The insulation is continuous and identical from end to end of the line. In every respect except shape, Nonpareil Cork Fitting Covers are exactly the same as the pipe covering, and are so accurately made that they join to the pipe insulation without a break. Consequently, there is no opportunity for moisture to condense, as is certain to occur when fittings are left bare or are covered with some material not identical with the pipe insulation.

Nonpareil Cork Covering is Easy to Apply

Light in weight, structurally strong and made in 36-inch half sections for the ordinarily used pipe sizes, Nonpareil Cork Covering can be quickly and easily put in place on the lines. Except for the very large sizes, Nonpareil Fitting Covers are also made in two molded sections ready to apply. Joints are sealed with Nonpareil Waterproof Cement and the covering wired in place. The seams are

smoothed with Nonpareil Seam Filler and the whole finished with Nonpareil Cork Covering Paint. Only the simplest of tools are needed, and there are no extras to buy, sufficient sundries for proper application being furnished and shipped with the covering.

Nonpareil Cork Covering is a *molded* covering made to the most accurate measurements. It fits, not approximately, but exactly on all sizes of pipes. With the same close attention to detail, fitting covers are made for every standard fitting used—brine, ammonia and extra heavy, screwed and flanged. These are applied in exactly the same way as the sectional covering is put on the pipes. The whole process is simple and easily understood, and by following the instructions sent with each shipment, good workmen should have no difficulty in making an air-and moisture-tight job at very reasonable labor cost.

Nonpareil Cork Covering is Slow Burning

Cork is a fire retardant. It will burn only as long as flame is applied from an external source. It will not support combustion nor will it smolder or carry fire. This is a very important point. Cases have been known where smoldering fire in pipe covering made of other materials has traveled from one part of a building to another.

An instance showing the almost fireproof quality of Nonpareil Covering occurred in the plant of the Frankfort Ice Company, Frankfort, Indiana. Though exposed to a hot fire of some four hours' duration, the Nonpareil Cork Covering suffered no further damage than the melting off of the finish. None of the covering had to be removed. After being cleaned and painted, the insulation was practically as good as before the fire, and is still in service ten years after application and four years after the fire.

Reasonable in Cost

Nonpareil Cork Covering is not expensive in cost of material, application, or maintenance.

One thing is certain: *To operate economically and to maintain the desired temperatures, every refrigerated drinking water system must be well insulated.* There are pipe coverings on the market the first cost of which, for material, is somewhat less than that of Nonpareil Cork Covering. Some of them cannot by any method be applied so that they will be moisture-proof. Others can be, but only by a laborious process of winding and waterproofing on the line, the labor cost of which more than offsets the difference in the material cost. Nonpareil Cork Covering is molded to fit and is moisture-proofed at the factory. It is easily and quickly applied at small labor expense. Its cost on the line is no greater, and is usually less, than for any other type of pipe insulation comparable to it in efficiency and durability.

Nonpareil Cork Covering costs practically nothing to maintain. It stays dry. There is nothing about it to deteriorate. It has no depreciation. An annual inspection to





The General Motors Building, Detroit. Refrigerated drinking water is circulated through this immense building and kept cold in the lines by Nonpareil Cork Covering

see that the wires are tight and a coat of Nonpareil Cork Covering Paint as needed are all the attention required.

Service Details

Nonpareil Cork Covering is made in three thicknesses for different service conditions, only two of which are used on a drinking water system. These are as follows:

ICE WATER THICKNESS—For refrigerated drinking water lines and generally where the temperature carried is above 25° F.

BRINE THICKNESS—For brine, ammonia, carbon dioxide and other low temperature gas or liquid lines where the refrigerant ranges from 0° to 25° F. In a drinking water system Brine Thickness is used on lines between the refrigerating machines and the cooling tanks.

SPECIAL THICK BRINE—For cold lines where the temperature of the refrigerant is below 0° F. This thickness is seldom used in connection with drinking water apparatus, except when unusual outside conditions exist.

For Tanks and Coolers

Cylindrical tanks and coolers for refrigerated water, etc., are insulated with Nonpareil Cork Lagging and Discs which, except in form is the same material as Nonpareil Cork Covering.

Nonpareil Cork Lagging is supplied in 36-inch lengths of the proper width and bevel for the equipment to be insulated. Thicknesses range from 1½ inches to 8 inches. Discs of the same thicknesses are also made up in the required size for insulating tank heads. Both lagging and discs are coated inside and out with mineral rubber.

The proper thickness of Nonpareil Cork Lagging to apply for a given temperature depends on several factors, which vary in the case of each plant, viz.: cost of producing refrigeration, climatic conditions, etc. Under average conditions, however, it has been found economical to use the two-inch thickness on cooling-water tanks.

Baudelot Cooler Rooms

Where a Baudelot cooler is used (see page 20) the room itself must be insulated. For this purpose Armstrong's Nonpareil Corkboard is used, applied on the walls, floor, and ceiling. The method of erection will depend on the construction of the room, and specific information will be supplied on request.

Contract Department

The Company maintains a Contract Department with experienced erection superintendents and foremen. This department does not undertake the erection or supplying of any equipment—refrigeration, piping, tanks, fountains, etc.—other than the insulation. It is, however, prepared to handle all insulation contracts, large and small, promptly, efficiently, and at reasonable cost.

This service is a distinct advantage to the owner in that it affords him the assurance, backed by the Company's experience, that his covering will be put on carefully and properly. The responsibility for the workmanship which is so important a factor in low-temperature insulation is in this way placed where it belongs — on those who are responsible for the high quality of the material, and who, equally with the owner, are interested in seeing that it is so used that its maximum value may be realized.

Specifications for Nonpareil Cork Covering and Lagging

To insure the proper application of adequate insulation on all lines and apparatus, the following specifications should be used.

Specification No. 1

INSULATION OF REFRIGERATED PIPING

1. After all the pipe lines have been tested and made tight, they shall be covered with Nonpareil Cork Covering and Fitting Covers of proper thickness as outlined in the following schedule:

For temperatures from 25° F. up—Ice Water Thickness.

For temperatures from 0° F. to 25° F.—Brine Thickness.

For temperatures from 0° F. to minus 35° F.—Special Thick Brine.

2. All foreign matter such as plaster shall be removed from all pipe surfaces before covering is applied. Under no circumstances shall pipes be covered while wet or in a frosted condition.

3. Sectional covering shall be applied with all end joints broken by making one half of the first section 18 inches long and leaving the other half 36 inches in length. (Fig. IX). All longitudinal joints shall be on the top and bottom of the pipe and not along the sides. The covering shall be applied with Nonpareil Waterproof Cement on all joints and wired in place with copper-clad steel wire using not less than six wires to a section.

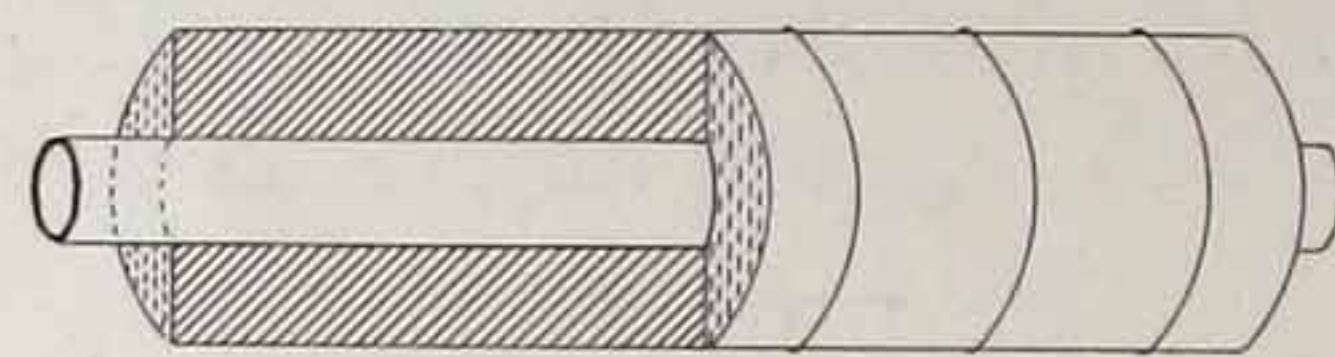


Fig. IX

4. Molded fitting covers shall be applied with Nonpareil Waterproof Cement on all joints and wired in place with copper-clad steel wire using not less than four wires on screwed fittings and six wires on flanged fittings. (Figs. X, XI and XII). All spaces between covers and fittings shall be carefully filled with Nonpareil Brine Putty.

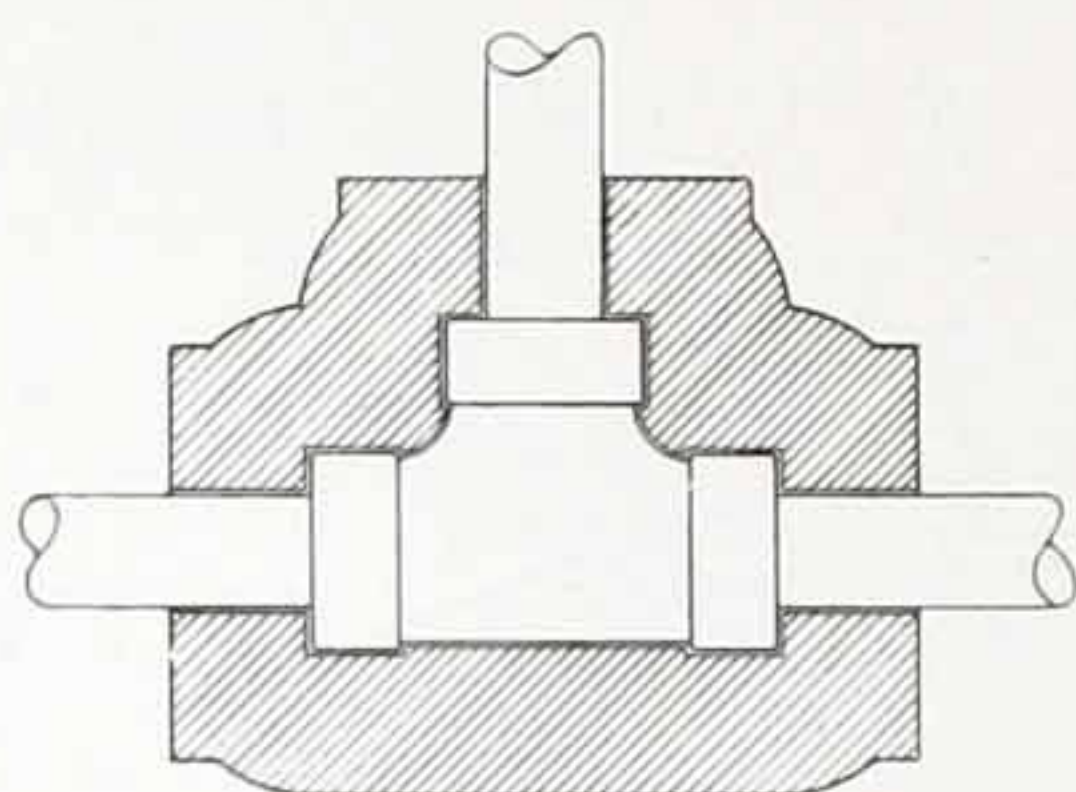


Fig. X

5. After the covering is applied, all seams and chipped edges shall be filled with Nonpareil Seam Filler so as to leave a smooth and even surface. The whole shall then be given one good coat of Nonpareil Cork Covering Paint.

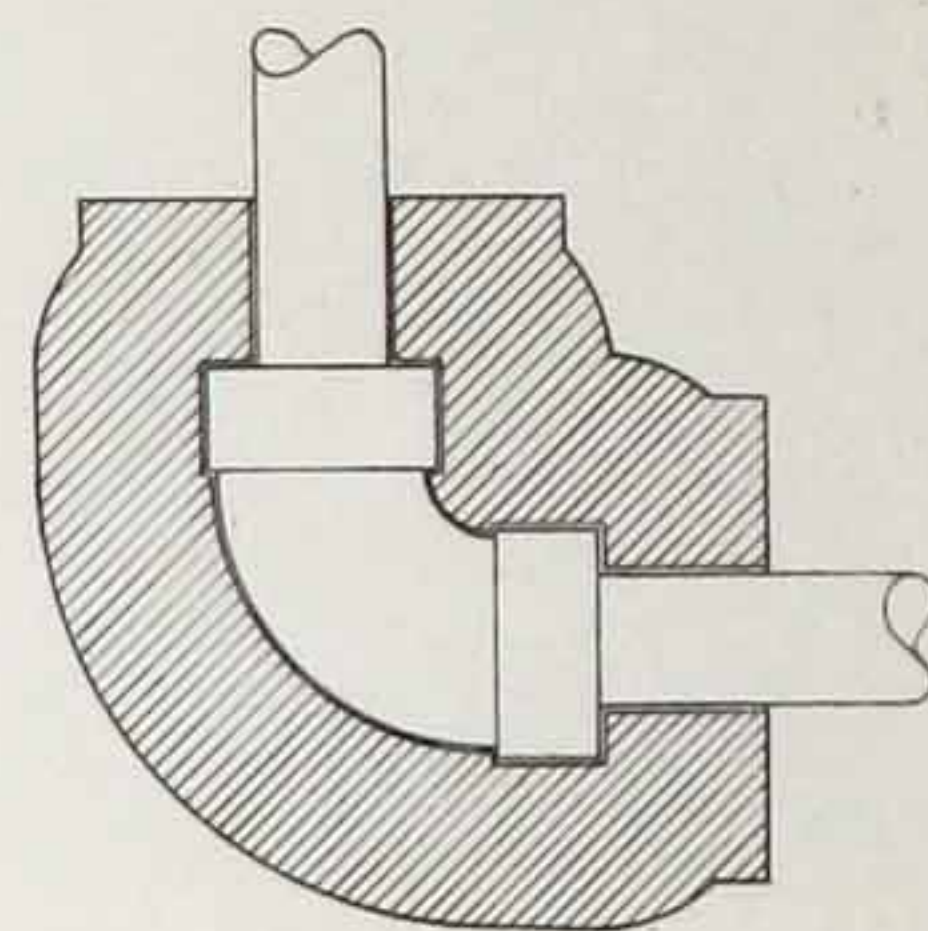


Fig. XI

NOTE 1—In all cases where a pipe passes through an insulated wall into a refrigerated room the covering shall extend one inch beyond the wall inside the room.

NOTE 2—Wall and floor openings for insulated pipes must be large enough to allow the full thickness of the covering to be used.

NOTE 3—All pipe hangers must be on the outside of the covering.

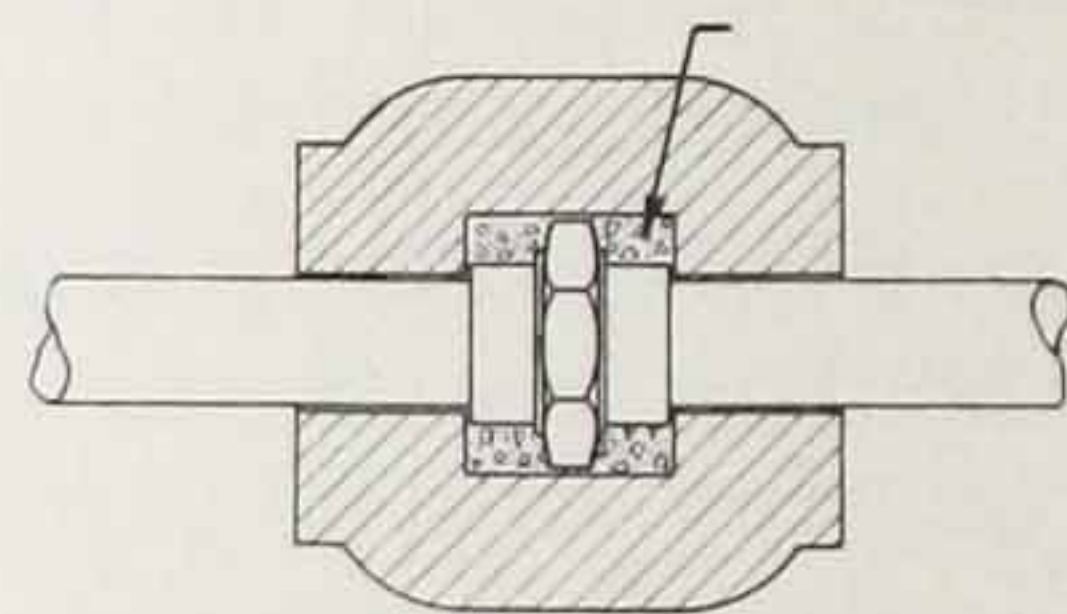


Fig. XII

Specification No. 2

INSULATION OF CYLINDRICAL COOLERS AND TANKS

6. Nonpareil Cork Lagging, 2 inches thick,* shall be used on all refrigerated water tanks, applied as follows:

7. After the tank has been tested and made tight, its cylindrical surface shall be insulated with one layer of Nonpareil Cork Lagging, 2 inches thick, weighing not less than 1.2 pounds per board foot. The lagging shall be beveled to the proper radius and shall have a mineral-rubber finish on both the inner and outer surfaces, which finish shall be ironed on at the factory.

The lags shall be applied with Nonpareil Waterproof Cement on all joints and secured in place with one-inch bands of sixteen-gauge steel, drawn up tight by means of bolts and clips riveted to the ends of the bands. (Fig. XIII). The bands shall be spaced not more than twelve inches apart. The transverse joints between the lags shall be broken. All spaces between the tank and the lagging shall be filled with Nonpareil Brine Putty.

The bottom of the tank shall be insulated with a disc of Nonpareil Cork Lagging 2 inches in thickness, cemented together with Nonpareil Waterproof

Cement. The top is to be insulated with a similar disc, (or provided with a wood cover) divided into two semi-circular pieces, and drilled for pipe connections along the center line. Both the top and bottom discs shall have a mineral rubber finish on the inner and outer surfaces, which finish shall be ironed on at the factory. Both bottom and tops discs shall be 4 inches greater in diameter than the outside diameter of the tank so that the disc will overlap the ends of the side lagging.

All seams and chipped edges shall be filled with Nonpareil Seam Filler so as to leave a smooth, even surface. The whole shall be given one good coat of Nonpareil Cork Covering Paint.

*—NOTE—It is permissible to use Armstrong's Corkboard, 3 inches thick, in place of 2-inch Lagging.

Specification No. 3

WEATHERPROOFING

8. Weatherproofing as hereinafter specified (Section 13) shall be applied over the Nonpareil Cork Covering on all refrigerated piping which is

9. Located outdoors or otherwise exposed to weather conditions;

10. In refrigerated rooms;

11. Exposed to wet or steamy atmosphere, as in dairies, laundries, kitchens, etc.;

12. Run in tunnels or underground trenches.

NOTE—If tunnel or trench is well drained and ventilated, ignore Section 12.

13. The weatherproofing shall consist of one layer of two-ply roofing applied with a 3-inch lap on all joints. The laps in every instance should be made so as to form a water-shed. All laps shall be cemented with Nonpareil Cork Covering Paint and additionally secured with copper staples. The weather-proofing shall be finished with one coat of Nonpareil Cork Covering Paint.

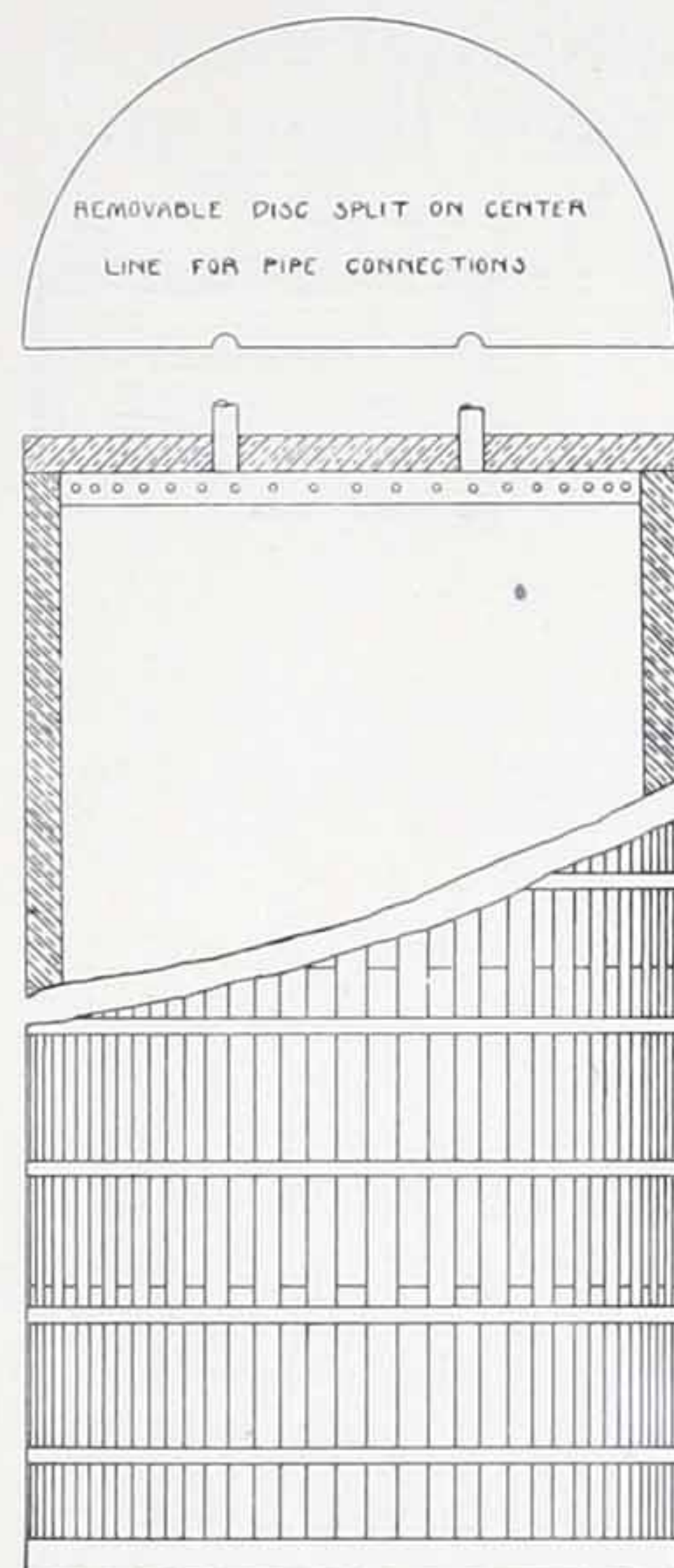


Fig. XIII

ARMSTRONG CORK & INSULATION COMPANY

Twenty-fourth Street and Allegheny River

Offices

ALBANY
ATLANTA
BIRMINGHAM, ALA.
BOSTON
BUFFALO
CHARLOTTE, N. C.
CHICAGO
CINCINNATI
CLEVELAND
DALLAS

DENVER
DETROIT
GRAND RAPIDS, MICH.
HARTFORD, CONN.
HOUSTON
INDIANAPOLIS
JACKSONVILLE, FLA.
KANSAS CITY, MO.
LOUISVILLE, KY.
MEMPHIS

MILWAUKEE
MINNEAPOLIS
NEW YORK
OMAHA
PITTSBURGH
ROCHESTER
ST. LOUIS
TULSA, OKLA.
MONTREAL, QUE., CAN.
TORONTO, ONT., CAN.

ARMSTRONG CORK COMPANY, LTD.
SARDINIA HOUSE, KINGSWAY, LONDON, W. C. 2
ENGLAND

Representatives

J. R. LIVEZEY, Baltimore, Md.
GAY ENGINEERING CORP., Los Angeles, Calif.
H. T. STEFFEE, New Orleans, La.
J. R. LIVEZEY, Philadelphia, Pa.

D. E. FRYER & Co., Spokane, Wash.
GILLEN-COLE COMPANY, Portland, Ore.
VAN FLEET-FREEAR Co., San Francisco, Cal.
D. E. FRYER & COMPANY, Seattle, Wash.

D. E. FRYER & COMPANY, Tacoma, Wash.

APPENDIX

Specimen Calculation

Assume a plant consisting of two main buildings, single story, with a power plant located approximately between them. One building requires a circuit of 2000 feet to supply 300 men; the other a 600-foot circuit for 100 men. The main supply from the tank to the branches is 100 feet. The water is to have a temperature of 45° F. at the supply end of each branch with a maximum permissible rise of 5° F. The average mill temperature is 95° F., and the average difference in temperature between the air and water, 47.5° F. The quantity of water required per man, per hour is .25 gallons. Figure I shows the layout.

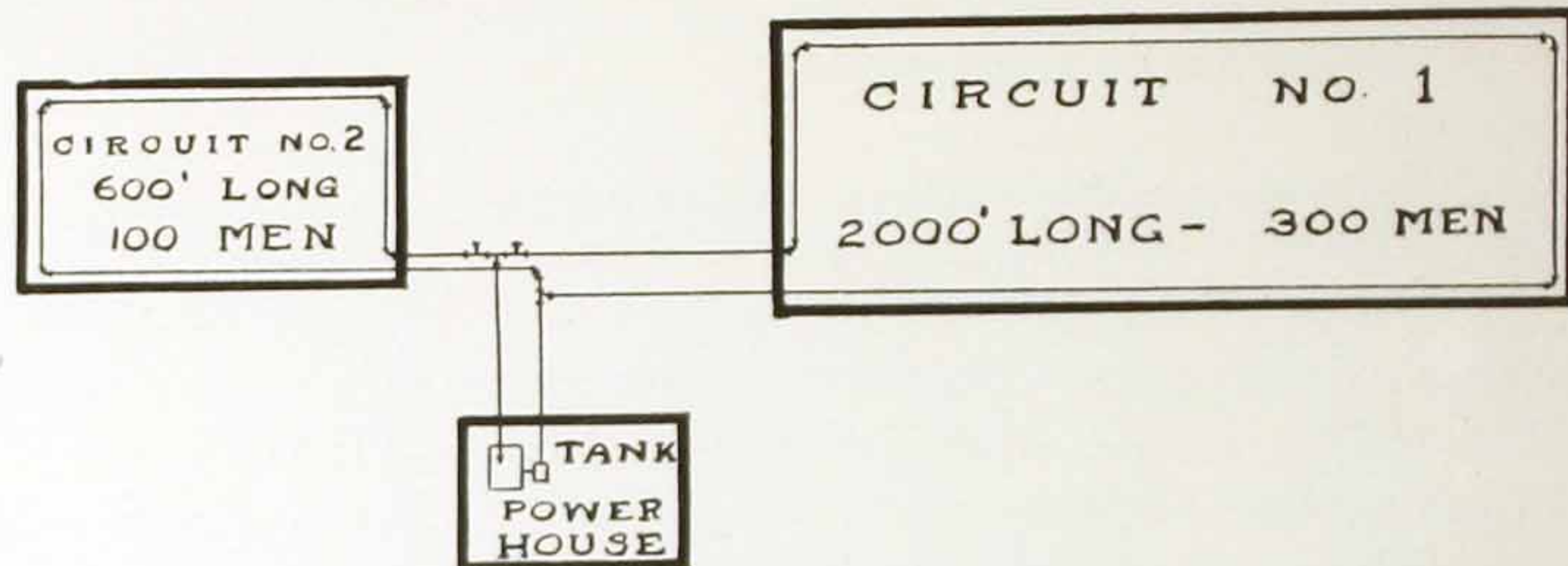


Fig. I

NUMBER 1 CIRCUIT

Length of Circuit, 2,000 feet. Number of men, 300.

Since 1-inch pipe can generally be used on such a circuit, assume that size as a basis for calculation. If later it should be shown that a 1-inch line will not supply the required volume at a velocity of 190 feet per minute, or less, a larger pipe size will have to be used.

Mill workers consume (use and waste) up to .25 gallons per hour. Weather and working conditions may reduce this somewhat, but allowance must be made for the maximum requirement. Water consumed will therefore be

$$.25 \text{ gallons} \times 300 = 75 \text{ gallons per hour.}$$

In addition to the water drawn off at the outlets, water must be circulated to carry away the heat that is absorbed by the line. This quantity depends upon the permissible rise in temperature in the circuit and upon the efficiency of the insulation. (It is assumed that the lines are covered with Nonpareil Cork Covering, Ice Water Thickness. Any less efficient insulation would correspondingly increase the heat leakage and therefore the volume of water to be circulated.)

Heat is absorbed through 1-inch Ice Water Thickness Cork Covering at the rate of .152 B.t.u. per lineal foot, per degree difference in temperature, per hour. The temperature difference in this case is 47.5 degrees, and the heat absorption for this line is therefore

$$2000 \times 47.5 \times .152 = 14,400 \text{ B.t.u. per hour.}$$

Since 1 B.t.u. is required to raise the temperature of 1 pound of water 1 degree, and a 5-degree rise is allowed for in this line, it follows that the quantity of water to be circulated is

$$14,400 \div 5 = 2880 \text{ pounds per hour}$$

or

$$2880 \div 8.3 \text{ (pounds per gallon)} = 347 \text{ gallons per hour.}$$

The total amount of water required is therefore—

75 gallons, used and wasted

347 gallons, circulated

422 gallons per hour.

The velocity can now be checked for the pipe size assumed:

$$422 \div 60 \text{ (minutes)} \div 7.48 \text{ (gallons per cubic foot)} = .94 \text{ cubic feet per minute.}$$

Inside cross sectional area of 1-inch pipe = .006 square feet.

$$\text{Velocity at supply end } \left(V = \frac{Q}{A} \right) = \frac{.94}{.006} = 157 \text{ feet per minute.}$$

This velocity is well within the safe limit. Had it run over 190 feet by any considerable amount, it would be necessary to substitute the next larger pipe and repeat the calculation.

NUMBER 2 CIRCUIT

The formulae used are the same as for Circuit No. 1.

Length of circuit, 600 feet. Number of men, 100.

Although the requirements are less than for Circuit No. 1, it is not advisable to use smaller than 1-inch pipe on account of the almost unavoidable constriction of the pipe area due to the burrs formed in cutting the pipe.

Water required (used and wasted):

$$100 \times .25 = 25 \text{ gallons per hour.}$$

Total heat absorption by line:

$$600 \times 47.5 \times .152 = 4330 \text{ B.t.u. per hour.}$$

Gallons of water to be circulated to limit the temperature rise to 5 degrees:

$$4330 \div 5 = 866 \text{ (pounds)} \div 8.3 = 104 \text{ gallons per hour.}$$

Total volume of water

25 gallons used and wasted

104 gallons for heat removal

129 gallons per hour.

Checking for velocity

$$129 \text{ (gallons)} \div 60 \text{ (minutes)} \div 7.48 = .29 \text{ cubic feet per minute.}$$

$$\text{Velocity } \left(V = \frac{Q}{A} \right) = \frac{.29}{.006} = 48 \text{ feet per minute.}$$



Canvas-covered Nonpareil Cork Covering on the drinking water lines at the United Drug Company, St. Louis

MAIN CIRCUIT

It is necessary to use at least $1\frac{1}{4}$ -inch pipe to supply the two 1-inch branches. Checking for velocity,

Length of circuit, supply and return, 200 feet.

Quantity of water:

Circuit No. 1— .94 cubic feet per minute

Circuit No. 2— .29 cubic feet per minute

1.23 cubic feet per minute.

Inside cross-sectional area of $1\frac{1}{4}$ -inch pipe = .0104 sq. ft.

Velocity $\left(V = \frac{Q}{A}\right) = \frac{1.23}{.0104} = 118$ feet per minute.

TABULATION OF REQUIREMENTS

It is well at this point to summarize the data so far obtained together with other related data. Such a tabulation gives a complete picture of the supply and circulation system and serves as a check against the omission of any item in the discussion of the system or purchase of material. It also affords sufficient data for the selection of pumps, filters, sterilizers, cooling tanks, etc.

Circuit	Length Feet	Pipe Size Inches	Em- ployees	Velocity Feet per Minute	Line Loss B. t. u.	Water Used Gallon per Hour	Water Circulated Gallon Hour	Pump Gallon per Minute	Friction Head Pipe*	Friction Head Fittings	Grav-ity Head
No. 1	2000	1	300	157	14400	75	347	7.03	96	13	0
No. 2	600	1	100	48	4330	25	104	2.16	6	2	0
Main	200	1¼		118	1640				5	3	18
Totals	2600—1" 200—1¼"		400		20370	100	451	9.19	107	18	18

*—See Friction Table on page 44.
No. of fittings, 5% of feet of pipe.

TOTAL HEAD 143 Feet.

REFRIGERATION—The refrigeration required is that which is necessary to cool the make-up water and the returned circulated water from their entering temperatures to the tank temperature; or in other words, to extract the heat brought in by the fresh water supply and that absorbed along the lines, in pumps, and other apparatus.

In the Main Circuit, the temperature of the supply water is 45°, making a temperature difference of 50° (95 – 45). The heat absorption through 1¼" Ice Water Thickness Cork Covering is .173 B.t.u.

$$100 \times .173 \times 50 = 865 \text{ B.t.u. per hour.}$$

The temperature of the return water being 50°, the temperature difference is 45° (95 – 50).

$$100 \times .173 \times 45 = 778 \text{ B.t.u. per hour.}$$

Quantity of water supplied to circuits is:

$$\text{Circuit No. 1—} 422 \text{ gal.} \times 8.3 = 3500 \text{ pounds per hour}$$

$$\text{Circuit No. 2—} 129 \text{ gal.} \times 8.3 = 1070 \text{ pounds per hour}$$

$$\text{Total.....} 4570 \text{ pounds per hour.}$$

Since the heat absorption in the main supply is 865 B.t.u. and 1 B.t.u. is required to raise the temperature of 1 pound of water 1 degree, the rise in temperature in the supply line will be

$$865 \div 4570 = .19 \text{ degrees.}$$

As the water is to enter the circuits at 45° its temperature in the tank must be

$$45^\circ - .19^\circ = 44.81^\circ$$

Quantity of water returned is

$$\text{Circuit No. 1—} 347 \times 8.3 = 2880 \text{ pounds per hour}$$

$$\text{Circuit No. 2—} 104 \times 8.3 = 866 \text{ pounds per hour}$$

$$\text{Total.....} 3746 \text{ pounds per hour.}$$

Rise in temperature in main return

$$778 \div 3746 = .21 \text{ degrees.}$$

Temperature of return water at tank

$$50^\circ + .21^\circ = 50.21 \text{ degrees.}$$



Assume the temperature of water from the source of supply (well or city line) to be 75 degrees. It will be necessary to cool this fresh, or make-up, water from 75 degrees to 44.81 degrees, and to cool the return water from 50.21 degrees to 44.81 degrees. There will also be small losses from the pump, tanks, and other equipment.

The total water used and wasted is

100 gallons $\times$ 8.3 = 831 pounds per hour, to be cooled
30.19 degrees (75 - 44.81).

$830 \times 30.19 = 25,000$ B.t.u. — heat removed from make-up water.

Total return water is

452 gallons $\times$ 8.3 = 3750 pounds per hour, to be cooled
5.4 degrees (50.21 - 44.81).

$3750 \times 5.4 = 20,200$ B.t.u. — heat removed from return water.

Total heat to be removed

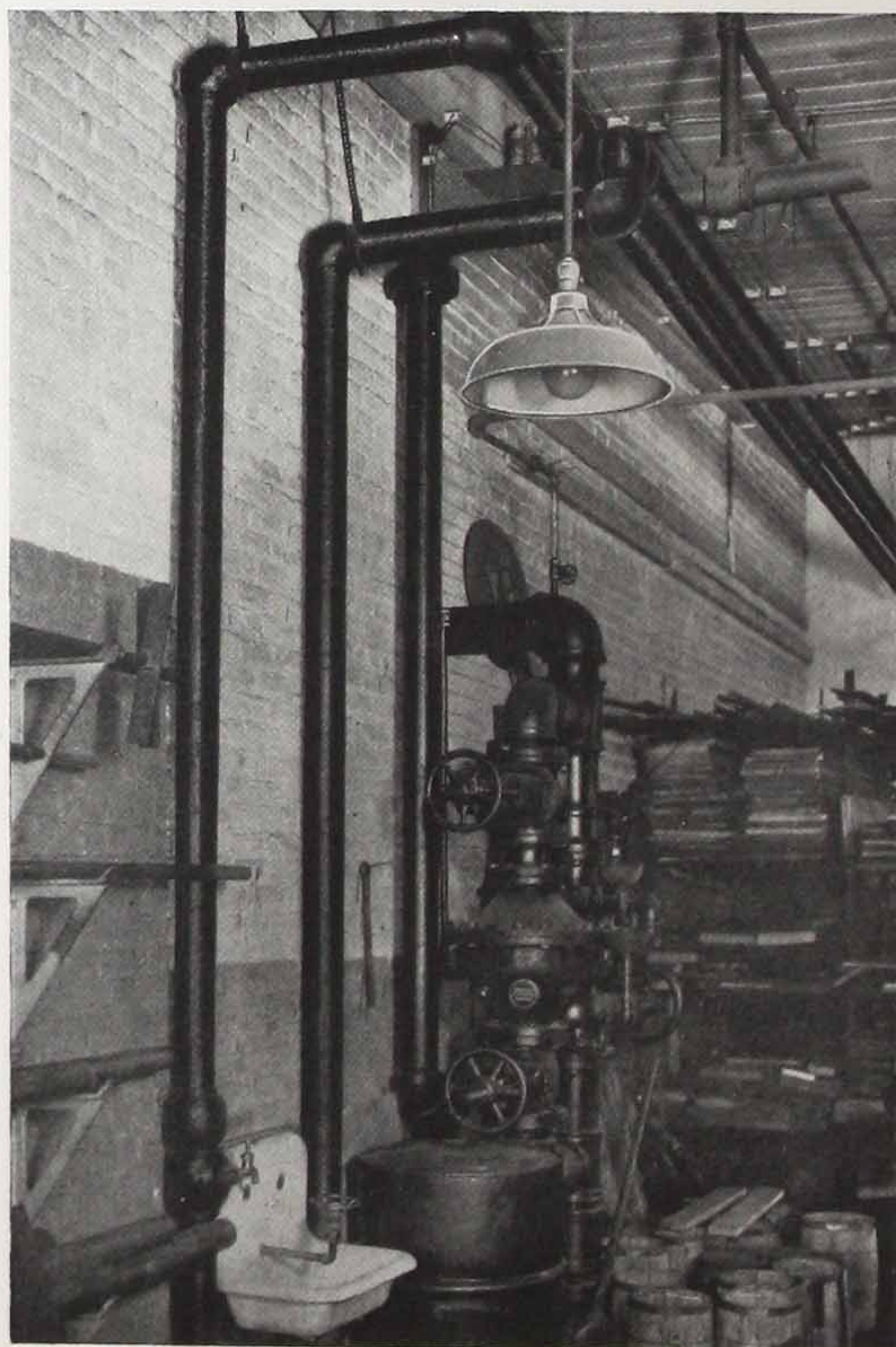
$25000 + 20200 = 45,200$ B.t.u. per hour.

Since one ton of refrigeration is the equivalent of 288,000 B.t.u. per 24 hours,

$45,200 \times 24 \div 288,000 = 3.76$ tons — refrigeration required to cool the entire water supply.

This example is given to illustrate the method of calculating the cooling effect required and the amount of refrigeration shown is only that needed for the make-up water and line losses.

Actual calculations for specific cases and the selection of machine sizes must be left to the refrigeration contractors estimating on the work.



The Nonpareil Cork covered lines in the plant of the Manning Paper Company, Green Island, N. Y.

PROPERTIES OF SATURATED AMMONIA
Adapted from U. S. Bureau of Standards Tables

Gage Pressure lbs./sq. in.	Temp. ° F.	Absolute Pressure lbs./sq. in.	Volume Vapor cu. ft./lb.	Density Vapor lbs./cu. ft.	Heat Content		Latent Heat B.t.u. per lb.
					Liquid B.t.u./lb.	Vapor B.t.u./lb.	
20*	—63.9	4.9	50.5	.0198	—25.3	588.0	613.3
15*	—51.4	7.4	34.5	.0290	—12.2	593.1	605.3
10*	—42.1	9.8	26.3	.0380	— 2.2	596.8	509.0
5*	—34.5	12.2	21.4	.0468	5.9	599.6	593.7
0	—28.0	14.7	18.0	.0555	12.8	602.1	589.3
5	—17.2	19.7	13.7	.0730	24.4	606.0	581.6
10	— 8.4	24.7	11.1	.0902	33.8	609.0	575.2
15	— 1.0	29.7	9.32	.107	41.9	611.4	596.5
20	5.5	34.7	8.06	.124	48.9	613.5	564.6
25	11.3	39.7	7.11	.141	55.3	615.3	560.0
30	16.6	44.7	6.35	.158	61.0	616.8	555.8
35	21.4	49.7	5.74	.174	66.3	618.2	551.9
40	25.8	54.7	5.25	.191	71.2	619.4	548.2
45	30.0	59.7	4.83	.207	75.7	620.5	544.8
50	33.8	64.7	4.48	.224	80.0	621.5	541.5
55	37.5	69.7	4.17	.240	84.0	622.4	538.4
60	40.9	74.7	3.91	.256	87.8	623.2	535.4
65	44.2	79.7	3.67	.273	91.5	624.0	532.5
70	47.3	84.7	3.47	.289	94.9	624.6	529.7
75	50.3	89.7	3.28	.305	98.3	625.3	527.0
80	53.1	94.7	3.11	.322	101.5	625.9	524.4
85	55.9	99.7	2.96	.338	104.5	626.5	522.0
90	58.5	104.7	2.82	.354	107.5	627.0	519.5
95	61.1	109.7	2.70	.370	110.4	627.5	517.1
100	63.5	114.7	2.59	.387	113.2	628.0	514.8
110	68.2	124.7	2.39	.419	118.5	628.8	510.3
120	72.6	134.7	2.21	.452	123.5	629.5	506.0
130	76.7	144.7	2.06	.484	128.2	630.2	502.0
140	80.6	154.7	1.93	.517	132.7	630.8	498.1
150	84.4	164.7	1.82	.550	137.0	631.3	494.3
160	88.0	174.7	1.72	.582	141.1	631.8	490.7
170	91.4	184.7	1.62	.615	145.1	632.1	487.0
180	94.7	194.7	1.54	.648	148.9	632.5	483.6
190	97.8	204.7	1.47	.681	152.6	632.8	480.2
200	100.9	214.7	1.40	.714	156.2	633.1	476.9
225	108.0	239.7	1.25	.797	164.6	633.6	469.0
250	114.6	264.7	1.13	.881	172.6	633.9	461.3
275	120.8	289.7	1.03	.966	179.9	634.0	454.1
300	126.5	314.7	.95	1.052	187.0	633.9	446.9

* Inches of mercury below one standard atmosphere (29.92 in.)

PROPERTIES OF SATURATED CARBON DIOXIDE

(Amagat—Mollier)

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Temperature Deg. F.	Pressure, Absolute, Lb. per Sq. In.	Volume Cu. Ft. per Lb.	Weight Lb. per Cu. Ft.	Latent Heat Above 32° F., B.t.u. per Lb.		
				of Liquid	of Vapor	Total
—22	213.0	0.4323	2.32	—25.72	126.13	100.14
—13	248.5	.3674	2.73	—21.87	122.67	100.80
— 4	288.3	.3132	3.19	—17.87	118.86	100.99
+ 5	333.7	.2674	3.74	—13.73	114.71	100.98
14	384.8	.2286	4.37	— 9.38	110.12	100.74
23	440.2	.1952	5.12	— 4.82	105.04	100.22
32	502.7	.1669	6.00	0.00	99.34	99.34
41	573.3	.1422	7.03	5.17	92.91	98.08
50	648.9	.1205	8.30	10.76	85.54	96.30
59	732.7	.1010	9.90	17.01	76.84	93.85
68	825.0	.0840	11.92	24.21	66.15	90.36
77	928.7	.0672	14.85	33.19	51.91	85.10
86	1038.0	.0474	21.09	47.50	26.88	74.38
87.8	1060.7	.0412	24.27	53.77	15.04	68.81
88.4	1069.3	.0346	28.95	61.45	0.00	61.45

PROPERTIES OF SATURATED SULPHUR DIOXIDE

(Cailletet and Mathias)

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Temperature Deg. F.	Pressure, Absolute, Lb. per Sq. In.	Volume Cu. Ft. per Lb.	Weight Lb. per Cu. Ft.	Latent Heat Above 32° F., B.t.u. per Lb.		
				of Liquid	of Vapor	Total
—40	3.12	22.715	0.044	—21.33	178.56	157.23
—31	4.26	17.121	.058	—18.83	177.36	158.53
—22	5.54	13.177	.076	—16.29	175.99	159.70
—13	7.24	10.307	.096	—13.72	174.42	160.70
— 4	9.23	8.223	.122	—11.07	172.66	161.59
— 5	11.79	6.668	.150	— 8.39	170.68	162.29
14	14.77	5.290	.189	— 5.65	168.48	162.83
23	18.32	4.328	.231	— 2.84	166.08	163.24
32	22.44	3.574	.280	0.00	163.48	163.48
41	27.40	2.950	.340	2.90	160.65	163.55
50	33.23	2.437	.411	5.85	157.61	163.46
59	39.90	2.036	.493	8.86	155.36	163.22
68	45.57	1.715	.585	11.92	150.93	162.85
77	56.23	1.443	.696	15.03	147.28	162.31
86	66.31	1.218	.824	18.20	143.80	161.60
95	77.53	1.042	.964	21.42	139.32	160.74
104	90.17	0.882	1.141	24.68	135.05	159.73

STANDARD WROUGHT IRON AND STEEL PIPE

(National Tube Table)

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Size Inches	Diameter		Wt. per Foot Lbs.	Cross Sectional Area			External Area per Lin. Ft.	Capacity per Lin. Ft.		
	External Inches	Internal Inches		External Sq. In.	Internal Sq. In.	Internal Sq. Ft.		Cu. Ft.	Gal.	Pounds Water
1/8	.405	.269	.244	.129	.057	.000396	.106—	.000396	.003	.025
1/4	.540	.364	.424	.229	.104	.000722	.142—	.000722	.005	.045
3/8	.675	.493	.567	.358	.191	.00132	.177—	.00132	.010	.083
1/2	.840	.622	.850	.554	.304	.00211	.22	.00211	.016	.132
3/4	1.050	.824	1.130	.886	.533	.0037	.276	.0037	.028	.231
1	1.315	1.049	1.678	1.358	.864	.006	.344	.006	.045	.375
1 1/4	1.660	1.380	2.272	2.164	1.495	.0104	.435	.0104	.078	.648
1 1/2	1.900	1.610	2.717	2.835	2.036	.0141	.498	.0141	.106	.883
2	2.375	2.067	3.652	4.430	3.355	.0232	.623	.0232	.174	1.455
2 1/2	2.875	2.469	5.793	6.492	4.788	.0332	.754	.0332	.249	2.076
3	3.500	3.068	7.575	9.621	7.393	.0513	.916	.0513	.384	3.205
3 1/2	4.000	3.548	9.109	12.566	9.886	.0686	1.05	.0686	.514	4.286
4	4.500	4.026	10.790	15.904	12.730	.0884	1.18	.0884	.661	5.519
4 1/2	5.000	4.506	12.538	19.635	15.947	.111	1.31	.111	.828	6.913
5	5.563	5.047	14.617	24.306	20.006	.139	1.46	.139	1.039	8.673
6	6.625	6.065	18.974	34.472	28.891	.2	1.74	.2	1.501	12.524
7	7.625	7.023	23.544	45.664	38.738	.269	2.00	.269	2.012	16.793
8	8.625	8.071	24.696	58.426	51.161	.355	2.26	.355	2.658	22.179
8	8.625	7.981	28.554	58.426	50.027	.348	2.26	.348	2.599	21.687
9	9.625	8.941	33.907	72.760	62.786	.436	2.52	.436	3.262	27.218
10	10.750	10.192	31.201	90.763	81.585	.567	2.82	.567	4.238	35.368
10	10.750	10.136	34.240	90.763	80.691	.56	2.82	.56	4.192	34.980
10	10.750	10.020	40.483	90.763	78.855	.547	2.82	.547	4.096	34.184
11	11.750	11.000	45.557	108.434	95.033	.66	3.08	.66	4.937	41.198
12	12.750	12.090	43.773	127.676	114.800	.796	3.34	.796	5.964	49.767
12	12.750	12.000	49.562	127.676	113.097	.785	3.34	.785	5.875	49.028
13	14.000	13.250	54.568	153.938	137.886	.957	3.68	.957	7.163	59.775
14	15.000	14.250	58.573	176.715	159.485	1.105	3.94	1.105	8.285	69.138
15	16.000	15.250	62.579	201.062	182.654	1.268	4.20	1.268	9.489	79.182
17 O. D.	17.000	16.214	69.704	226.980	206.476	1.432	4.47	1.432	10.726	89.509
18 O. D.	18.000	17.182	76.840	254.469	231.866	1.606	4.72	1.606	12.045	100.516
20 O. D.	20.000	19.182	85.577	314.159	288.986	2.007	5.27	2.007	15.012	125.278

FRICION OF WATER IN PIPES

Loss of head in feet due to friction, per 100 feet of smooth, straight cast iron pipe

Gallons per Min.	1/2-Inch Pipe		3/4-Inch Pipe		1-Inch Pipe		1 1/4-Inch Pipe		1 1/2-Inch Pipe		2-Inch Pipe		2 1/2-Inch Pipe		3-Inch Pipe		4-Inch Pipe	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
2	2.10	5.30	1.20	1.40	1.12	0.90	0.86	0.40	0.63	0.187	.51							
3	3.16	11.30	1.80	2.90	1.49	1.52	1.07	0.60	0.79	0.283	1.02							
4	4.21	19.20	2.41	5.00	1.86	2.32	1.44	2.18	1.57	1.02	1.53							
5	5.26	29.00	3.01	7.50	3.72	8.40	3.92	4.65	2.72	2.25	2.04	0.81	0.33	0.05	0.45	0.05		
10	10.52	105.00	6.02	27.10	6.13	18.90	4.29	7.90	3.15	3.70	2.55	1.29	0.65	0.12	0.68	0.11		
15			9.02	57.00	7.44	30.10	5.36	11.90	4.56	5.60	3.06	1.96	0.98	0.25	0.91	0.18		
20			12.03	97.00	9.30	45.50	6.43	16.90	4.72	7.80	3.57	2.73	1.31	0.43	1.13	0.27		
25					11.15	64.00	7.51	22.30	5.51	10.30	4.08	3.66	1.63	0.66	1.36	0.38		
30					13.02	85.00	8.58	28.50	6.30	13.30	3.57	4.68	1.96	0.92	1.59	0.51		
35					14.88	109.00	9.68	35.20	7.08	16.60	4.60	5.80	2.29	1.23	1.82	0.65		
40							10.72	43.20	7.87	20.20	5.11	7.10	2.62	1.57	2.02	0.80	1.02	0.16
45							15.01	81.00	11.02	37.60	7.66	13.20	2.95	1.97	2.27	0.98	1.17	0.20
50									15.80	42.70	10.21	14.90	3.30	2.38	3.18	1.83	1.28	0.24
70									15.74	73.00	12.25	25.60	4.60	4.42	3.41	2.11	1.79	0.45
75											15.30	54.00	6.54	5.07	3.41	2.11	1.92	0.52
100													7.84	8.60	4.54	3.52	2.55	0.88
120													9.80	12.00	5.45	4.97	3.06	1.22
125													11.43	13.01	5.68	5.40	3.19	1.33
150													13.07	18.72	6.80	7.72	3.84	1.82
175														23.70	7.92	9.75	4.45	2.40
200														30.90	9.08	12.80	5.11	3.12
225															10.42	16.00	6.32	4.72
250															11.28	19.70	6.40	4.80
270															12.45	22.70	6.90	5.50
275															12.70	23.60	7.03	5.71
300															13.62	27.10	7.66	6.70
350																	8.90	8.80
400																	10.20	11.30

When pipe is slightly rough, add 15 per cent. When very rough, add 30 per cent.
 Vel.—Velocity feet per second. Fric.—Friction head in feet.

FRICTION OF WATER IN ELBOWS

Loss of head in feet, due to friction in various sizes of smooth 90° elbows when discharging the given quantities of water

Gal. per Min.	1-Inch		1¼-Inch		1½-Inch		2-Inch		2½-Inch		3-Inch		4-Inch	
	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.	Vel.	Fric.
5	2.04	0.06	1.30	0.14										
10	4.08	0.22	2.60	0.21										
15	6.12	0.49	3.90	0.29	2.73	0.09								
20	8.16	0.87	5.20	0.52	3.64	0.16								
25	10.20	1.35	6.50	0.80	4.55	0.25	2.60	0.09						
30	12.24	1.95	7.80	1.15	5.46	0.36	3.06	0.13						
35	14.28	2.65	9.10	1.60	6.37	0.50	3.57	0.18	2.29	0.09				
40	16.32	3.46	10.40	2.05	7.28	0.64	4.05	0.23	2.62	0.11				
45			11.70	2.70	8.19	0.81	4.60	0.29	2.95	0.14	2.02	0.06		
50					9.10	0.99	5.11	0.35	3.30	0.18	2.27	0.08		
70					12.74	1.98	7.15	0.70	4.60	0.34	3.18	0.19	1.79	0.05
100							10.20	1.41	6.54	0.74	4.54	0.29	2.55	0.10
120							12.25	2.24	7.84	1.17	5.45	0.46	3.06	0.15
150							15.30	3.20	9.80	1.58	6.80	0.66	3.84	0.22
175									11.43	2.16	7.92	0.90	4.45	0.30
200									13.07	2.96	9.08	1.18	5.11	0.40
250											11.28	1.84	6.40	0.62
270											12.45	2.35	6.90	0.70
300											13.62	2.63	7.66	0.89
350													8.90	1.24
400													10.20	1.59

When pipe is slightly rough, add 15 per cent. When very rough, add 30 per cent.

Vel.—Velocity in feet per second. Fric.—Friction head in feet.

Table shows loss for one elbow, and is based on Weisbach's Formula for short radius bends.

TEMPERATURE CONVERSION TABLES

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-459.4 TO 0			0 TO 100			100 TO 1000			1000 TO 2000			2000 TO 3000		
C	F		C	F		C	F		C	F		C	F	
-273	-459.4		-17.7	0	32	38	100	212	260	500	932	1093	2000	3632
-268	-450		-17.2	1	33.8	43	110	230	265	510	950	1098	2010	3650
-262	-440		-16.6	2	35.6	49	120	248	271	520	968	1104	2020	3668
-257	-430		-16.1	3	37.4	54	130	266	276	530	986	1109	2030	3685
-251	-420		-15.5	4	39.2	60	140	284	282	540	1004	1115	2040	3704
-246	-410		-15.0	5	41.0	65	150	302	288	550	1022	1120	2050	3722
-240	-400		-14.4	6	42.8	71	160	320	293	560	1040	1126	2060	3740
-234	-390		-13.9	7	44.6	76	170	338	299	570	1058	1131	2070	3758
-229	-380		-13.3	8	46.4	83	180	356	304	580	1076	1137	2080	3776
-223	-370		-12.7	9	48.2	88	190	374	310	590	1094	1142	2090	3794
-218	-360		-12.2	10	50.0	93	200	392	315	600	1112	1149	2100	3812
-212	-350		-11.6	11	51.8	99	210	410	321	610	1130	1154	2110	3830
-207	-340		-11.1	12	53.6	104	220	428	326	620	1148	1160	2120	3848
-201	-330		-10.5	13	55.4	110	230	446	332	630	1166	1165	2130	3866
-196	-320		-10.0	14	57.2	115	240	464	338	640	1184	1171	2140	3884
-190	-310		-9.4	15	59.0	121	250	482	343	650	1202	1176	2150	3902
-184	-300		-8.8	16	60.8	127	260	500	349	660	1220	1182	2160	3920
-179	-290		-8.3	17	62.6	132	270	518	354	670	1238	1187	2170	3938
-173	-280		-7.7	18	64.4	138	280	536	360	680	1256	1193	2180	3956
-169	-273	-459.4	-7.2	19	66.2	143	290	554	365	690	1274	1198	2190	3974
-168	-270	-454	-6.6	20	68.0	149	300	572	371	700	1292	1204	2200	3992
-162	-260	-436	-6.1	21	69.8	154	310	590	376	710	1310	1209	2210	4010
-157	-250	-418	-5.5	22	71.6	160	320	608	382	720	1328	1215	2220	4028
-151	-240	-400	-5.0	23	73.4	166	330	626	387	730	1346	1220	2230	4046
-146	-230	-382	-4.4	24	75.2	171	340	644	393	740	1364	1226	2240	4064
-140	-220	-364	-3.9	25	77.0	177	350	662	404	750	1382	1231	2250	4082
-134	-210	-346	-3.3	26	78.8	182	360	680	410	760	1400	1237	2260	4100
-129	-200	-328	-2.8	27	80.6	188	370	698	415	770	1418	1242	2270	4118
-123	-190	-310	-2.2	28	82.4	193	380	716	421	780	1436	1248	2280	4136
-118	-180	-292	-1.6	29	84.2	199	390	734	426	790	1454	1253	2290	4154
-112	-170	-274	-1.1	30	86.0	204	400	752	432	800	1472	1259	2300	4172
-107	-160	-256	-0.6	31	87.8	210	410	770	438	810	1490	1264	2310	4190
-101	-150	-238	0	32	89.6	215	420	788	443	820	1508	1270	2320	4208
-96	-140	-220	0.5	33	91.4	221	430	806	449	830	1526	1275	2330	4226
-90	-130	-202	1.1	34	93.2	226	440	824	454	840	1544	1281	2340	4244
-84	-120	-184	1.6	35	95.0	232	450	842	460	850	1562	1286	2350	4262
-79	-110	-166	2.2	36	96.8	238	460	860	465	860	1580	1292	2360	4280
-73	-100	-148	2.7	37	98.6	243	470	878	471	870	1598	1297	2370	4298
-68	-90	-130	3.3	38	100.4	249	480	896	476	880	1616	1303	2380	4316
-62	-80	-112	3.8	39	102.2	254	490	914	482	890	1634	1308	2390	4334
-57	-70	-94	4.4	40	104.0	260	500	932	487	900	1652	1315	2400	4352
-51	-60	-76	4.9	41	105.8	266	510	950	493	910	1670	1320	2410	4370
-46	-50	-58	5.5	42	107.6	271	520	968	498	920	1688	1326	2420	4388
-40	-40	-40	6.0	43	109.4	277	530	986	504	930	1706	1331	2430	4406
-34	-30	-22	6.6	44	111.2	283	540	1004	510	940	1724	1337	2440	4424
-29	-20	-4	7.1	45	113.0	289	550	1022	515	950	1742	1342	2450	4442
-23	-10	14	7.7	46	114.8	295	560	1040	520	960	1760	1348	2460	4460
-17.7	0	32	8.2	47	116.6	301	570	1058	526	970	1778	1353	2470	4478
			8.8	48	118.4	307	580	1076	532	980	1796	1359	2480	4496
			9.3	49	120.2	313	590	1094	538	990	1814	1364	2490	4514
			9.7	50	122.0	319	600	1112	544	1000	1832	1371	2500	4532
			10.2	51	123.8	325	610	1130	550	1010	1850	1376	2510	4550
			10.7	52	125.6	331	620	1148	556	1020	1868	1382	2520	4568
			11.2	53	127.4	337	630	1166	562	1030	1886	1387	2530	4586
			11.7	54	129.2	343	640	1184	568	1040	1904	1393	2540	4604
			12.2	55	131.0	349	650	1202	574	1050	1922	1398	2550	4622
			12.7	56	132.8	355	660	1220	580	1060	1940	1404	2560	4640
			13.2	57	134.6	361	670	1238	586	1070	1958	1409	2570	4658
			13.7	58	136.4	367	680	1256	592	1080	1976	1415	2580	4676
			14.2	59	138.2	373	690	1274	598	1090	1994	1420	2590	4694
			14.7	60	140.0	379	700	1292	604	1100	2012	1427	2600	4712
			15.2	61	141.8	385	710	1310	610	1110	2030	1432	2610	4730
			15.7	62	143.6	391	720	1328	616	1120	2048	1438	2620	4748
			16.2	63	145.4	397	730	1346	622	1130	2066	1443	2630	4766
			16.7	64	147.2	403	740	1364	628	1140	2084	1449	2640	4784
			17.2	65	149.0	409	750	1382	634	1150	2102	1454	2650	4802
			17.7	66	150.8	415	760	1400	640	1160	2120	1460	2660	4820
			18.2	67	152.6	421	770	1418	646	1170	2138	1465	2670	4838
			18.7	68	154.4	427	780	1436	652	1180	2156	1471	2680	4856
			19.2	69	156.2	433	790	1454	658	1190	2174	1476	2690	4874
			19.7	70	158.0	439	800	1472	664	1200	2192	1483	2700	4892
			20.2	71	159.8	445	810	1490	670	1210	2210	1488	2710	4910
			20.7	72	161.6	451	820	1508	676	1220	2228	1494	2720	4928
			21.2	73	163.4	457	830	1526	682	1230	2246	1499	2730	4946
			21.7	74	165.2	463	840	1544	688	1240	2264	1505	2740	4964
			22.2	75	167.0	469	850	1562	694	1250	2282	1510	2750	4982
			22.7	76	168.8	475	860	1580	700	1260	2300	1516	2760	5000
			23.2	77	170.6	481	870	1598	706	1270	2318	1521	2770	5018
			23.7	78	172.4	487	880	1616	712	1280	2336	1527	2780	5036
			24.2	79	174.2	493	890	1634	718	1290	2354	1532	2790	5054
			24.7	80	176.0	499	900	1652	724	1300	2372	1538	2800	5072
			25.2	81	177.8	505	910	1670	730	1310	2390	1543	2810	5090
			25.7	82	179.6	511	920	1688	736	1320	2408	1549	2820	5108
			26.2	83	181.4	517	930	1706	742	1330	2426	1554	2830	5126
			26.7	84	183.2	523	940	1724	748	1340	2444	1560	2840	5144
			27.2	85	185.0	529	950	1742	754	1350	2462	1565	2850	5162
			27.7	86	186.8	535	960	1760	760	1360	2480	1571	2860	5180
			28.2	87	188.6	541	970	1778	766	1370	2498	1576	2870	5198
			28.7	88	190.4	547	980	1796	772	1380	2516	1582	2880	5216
			29.2	89	192.2	553	990	1814	778	1390	2534	1587	2890	5234
			29.7	90	194.0	559	1000	1832	784	1400	2552	1593	2900	5252
			30.2	91	195.8	565	1010	1850	790	1410	2570	1598	2910	5270
			30.7	92	197.6	571	1020	1868	796	1420	2588	1604	2920	5288
			31.2	93	199.4	577	1030	1886	802	1430	2606	1609	2930	5306
			31.7	94	201.2	583	1040	1904	808	1440	2624	1615	2940	5324
			32.2	95	203.0	589	1050	1922	814	1450	2642	1620	2950	

PRESSURE OF WATER AT DIFFERENT HEADS

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Feet Head of Water and Equivalent Pressure

Feet Head	Pounds per Sq. In.	Feet Head	Pounds per Sq. In.	Feet Head	Pounds per Sq. In.
1	.43	60	25.99	200	86.62
2	.87	70	30.32	225	97.45
3	1.30	80	34.65	250	108.27
4	1.73	90	38.98	275	119.10
5	2.17	100	43.31	300	129.93
6	2.60	110	47.64	325	140.75
7	3.03	120	51.97	350	151.58
8	3.40	130	56.30	400	173.24
9	3.90	140	60.63	500	216.55
10	4.33	150	64.96	600	259.85
20	8.66	160	69.29	700	303.16
30	12.99	170	73.63	800	346.47
40	17.32	180	77.96	900	389.78
50	21.65	190	82.29	1,000	433.09

Pressure and Equivalent Feet Head of Water

Pounds per Sq. In.	Feet Head	Pounds per Sq. In.	Feet Head	Pounds per Sq. In.	Feet Head
1	2.31	40	92.36	170	392.52
2	4.62	50	115.45	180	415.61
3	6.93	60	138.54	190	438.90
4	9.24	70	161.63	200	461.78
5	11.54	80	184.72	225	519.51
6	13.85	90	207.81	250	577.24
7	16.16	100	230.90	275	643.03
8	18.47	110	253.98	300	692.69
9	20.78	120	277.07	325	750.41
10	23.09	125	288.62	350	808.13
15	34.63	130	300.16	375	865.89
20	46.18	140	323.25	400	922.58
25	57.72	150	346.34	500	1154.48
30	69.27	160	369.43	1,000	2308.00

MISCELLANEOUS CONVERSION TABLES

1 gal. (U.S.) = 231 cu. in.				1 lb. = 4536 Kilograms.		
1 Imperial gal. (British) = 277.274 cu. in.						
1 cu. ft. water = 1728 cu. in. = 62.355 lbs. at 62° F.						
	Gal.	Cu. Ft.	Cu. In.	Pounds Water	Litres	Kilograms Water
1 Gal.	1.000	.1337	231.0	8.337	3.785	3.785
1 Cu. ft.	7.481	1.000	1728.	62.36	28.32	28.32
1 Cu. in.	.004329	.0005787	1.000	.036	.01639	.01639
1 Pound	.1199	.01604	27.71	1.000	.4541	.4541
1 Litre	.2642	.03531	61.02	2.202	1.000	1.000
1 Kilogram	.2642	.03531	61.02	2.202	1.000	1.000
	Gal. Per Sec.	Gal. Per Min.	Cu. Ft. Per Sec.	Cu. Ft. Per Min.	Litres Per Sec.	
1 Gal. per Sec.	1.000	60.00	.1337	8.022	3.785	
1 Gal. per Min.	.01667	1.000	.002228	.1337	.06308	
1 Cu. Ft. per Sec.	7.481	448.9	1.000	60.00	28.32	
1 Cu. Ft. per Min.	.1247	7.481	.01667	1.000	.4720	
1 Litres per Sec.	.2642	15.852	.03531	2.119	1.000	

Representative List of Installations

HOTELS, CLUBS AND APARTMENTS

- Lafayette Hotel, Little Rock, Ark.
New Del Monte Hotel and Cottages, Del Monte, Calif.
A. T. & S. F. Ry. Co.,—Harvey Houses, Los Angeles, Calif.
Elks, Club, Los Angeles, Calif.
Encino Country Club, Los Angeles, Calif.
Jonathan Club, Los Angeles, Calif.
Senator Hotel, Sacramento, Calif.
San Francisco Women's Club, San Francisco, Calif.

Cosmopolitan Hotel, Denver, Colo.
Army & Navy Club, Washington, D. C.
Ebbitt Hotel, Washington, D. C.
Grace Dodge Hotel, Washington, D. C.
Hotel Raleigh, Washington, D. C.
Meridian Mansions, Washington, D. C.
Metropolitan Club, Washington, D. C.
New Willard Hotel, Washington, D. C.
Shoreham Hotel, Washington, D. C.
Washington Hotel, Washington, D. C.

Atlanta Athletic Club, Atlanta, Ga.
Atlanta Biltmore Hotel, Atlanta, Ga.
Henry Grady Hotel, Atlanta, Ga.
Robert Fulton Hotel, Atlanta, Ga.

Bismark Hotel, Chicago, Ill.
Eitel Block (Bismarck Hotel, Metropolitan Office Bldg., and Palace Theater), Chicago, Ill.
Sherman House, Chicago, Ill.
Southern Hotel, Chicago, Ill.

Hotel Black Hawk, Davenport, Iowa.
Hotel Fort Des Moines, Des Moines, Iowa.
Hotel Savery, Des Moines, Iowa.

Columbia Club, Indianapolis, Ind.
Indianapolis Athletic Club, Indianapolis, Ind.
Brown Hotel, Louisville, Ky.

Jung Hotel, New Orleans, La.
Roosevelt Hotel, New Orleans, La.
Washington Hotel, Shreveport, La.

Belvedere Hotel, Baltimore, Md.
Caswell Hotel, Baltimore, Md.
Emerson Hotel, Baltimore, Md.
Hotel Rennert, Baltimore, Md.
New Howard Hotel, Baltimore, Md.
Southern Hotel, Baltimore, Md.
Stafford Hotel, Baltimore, Md.
Chevy Chase Club, Chevy Chase, Md.

Post Tavern, Battle Creek, Mich.
Webster Hall (Apartment Hotel), Detroit, Mich.
Masonic Temple, Detroit, Mich.
Morton Hotel, Grand Rapids, Mich.
Pantlind Hotel, Grand Rapids, Mich.

Edwards Hotel, Jackson, Miss.
Alladdin Hotel, Kansas City, Mo.

Kansas City Athletic Club, Kansas City, Mo.
Kansas City Club, Kansas City, Mo.
Newborn Hotel, Kansas City, Mo.
Chase Hotel, St. Louis, Mo.
Coronado Hotel, St. Louis, Mo.
Fairmont Hotel, St. Louis, Mo.
Forest Park Hotel, St. Louis, Mo.
Gatesworth Hotel, St. Louis, Mo.
Jefferson Hotel, St. Louis, Mo.
Melbourne Hotel, St. Louis, Mo.

Cornhusker Hotel, Lincoln, Nebr.
Lincoln Hotel, Lincoln, Nebr.

Franciscan Hotel, Albuquerque, New Mexico.

Buffalo Athletic Club, Buffalo, N. Y.
Lafayette Hotel, Buffalo, N. Y.
Roosevelt Hotel, New York, N. Y.
Niagara Hotel, Niagara Falls, N. Y.
Seneca Hotel (addition), Rochester, N. Y.
Van Curler Hotel, Schenectady, N. Y.

Hotel Charlotte, Charlotte, N. C.
O'Henry Hotel, Greensboro, N. C.
Sheraton Hotel, High Point, N. C.
Robert E. Lee Hotel, Winston-Salem, N. C.
Zinzendorf Hotel, Winston-Salem, N. C.

Ashtabula Hotel, Ashtabula, Ohio.
Business Men's Club, Cincinnati, Ohio.
Gibson Hotel, Cincinnati, Ohio.
Cleveland Hotel, Cleveland, Ohio.
Olmstead Hotel, Cleveland, Ohio.
Winton Hotel, Cleveland, Ohio.
Deshler Hotel, Columbus, Ohio.
Y. M. C. A. Building, Columbus, Ohio.
Greystone Court Apartments, Columbus, Ohio.
Miami Hotel, Dayton, Ohio.

Eugene Hotel, Eugene, Ore.
Benson Hotel, Portland, Ore.
Multnomah Hotel, Portland, Ore.
University Club, Portland, Ore.

Brunswick Hotel, Lancaster, Pa.
Benjamin Franklin Hotel, Philadelphia, Pa.
Y. M. C. A. Building, Philadelphia, Pa.

Francis Marion Hotel, Charleston, S. C.

Farragut Hotel, Knoxville, Tenn.
Peabody Hotel, Memphis, Tenn.

Dallas Athletic Club Building, Dallas, Texas.
Jefferson Hotel, Dallas, Texas.
Melrose Court, Dallas, Texas.
Stoneleigh Court, Dallas, Texas.
Y. W. C. A. Building, Galveston, Texas.
Plaza Hotel, Houston, Texas.
Davenport Hotel, Spokane, Wash.

Cordner's Cafeteria, Montreal, Quebec, Canada.
Mount Royal Hotel, Montreal, Quebec, Canada.
Windsor Hotel, Montreal, Quebec, Canada.

MANUFACTURING PLANTS

- Tennessee Coal, Iron & R. R. Company, Fairfield, Ala.
 Tennessee Coal, Iron & R. R. Company, Ensley, Ala.
 Goodyear Tire & Rubber Company, Los Angeles, Calif.
 The Fleischmann Company, Langdon, D. C.
 Corby Baking Company, Washington, D. C.
 General Baking Company, Washington, D. C.
 Holmes Bakery, Inc., Washington, D. C.
 The Ford Plant, Jacksonville, Fla.
 Union Electric Light & Power Company, Cahokia, Ill.
 Crane Company, Chicago, Ill.
 Western Shade Cloth Company, Chicago, Ill.
 General Electric Company, Fort Wayne, Ind.
 American Sheet & Tin Plate Company, Gary, Ind.
 Belknap Hardware & Mfg. Company, Louisville, Ky.
 City Baking Company, Baltimore, Md.
 Horn & Horn, Baltimore, Md.
 Koester's Bakery, Baltimore, Md.
 Mount Vernon Woodberry Mills, Baltimore, Md.
 Rice Bakery, Baltimore, Md.
 Schmidt Bakery, Baltimore, Md.
 Standard Sanitary Mfg. Company, Baltimore, Md.
 Bethlehem Steel Company, Sparrows' Point, Md.
 C. A. Briggs Company, Cambridge, Mass.
 Pocasset Manufacturing Company, Fall River, Mass.
 Seaconnet Mill, Fall River, Mass.
 Sanford Spinning Company, Fall River, Mass.
 Arcadia Mills, Lawrence, Mass.
 Arlington Mills, Lawrence, Mass.
 Ayer Mills, Lawrence, Mass.
 Monomac Spinning Company, Lawrence, Mass.
 Pacific Mills, Lawrence, Mass.
 Prospect Mills, Lawrence, Mass.
 Wool Worsted Mills, Lawrence, Mass.
 Hamilton Mfg. Company, Lowell, Mass.
 Tremont & Suffolk Mills, Lowell, Mass.
 Butler Mills, New Bedford, Mass.
 Manomet Mills, New Bedford, Mass.
 Nashawena Mills, New Bedford, Mass.
 Nonquitt Spinning Company, New Bedford, Mass.
 Quissett Mills, New Bedford, Mass.
 Sharp Manufacturing Company, New Bedford, Mass.
 Soule Mill, New Bedford, Mass.
 Stevens Mills, M. T. Stevens Company, North Andover, Mass.
 Ayer Mills, Mill No. 7, Shawsheen, Mass.
 Atlantic & Pacific Tea Company, Somerville, Mass.
 Judson-Thompson Mfg. Company, Waltham, Mass.
 Cadillac Motor Company, Detroit, Mich.
 Ford Motor Company, Detroit, Mich.
 American Car & Foundry Company, St. Louis, Mo.
 International Shoe Company, St. Louis, Mo.
 Peters Shoe Company, St. Louis, Mo.
 St. Louis Manufacturing Corporation, St. Louis, Mo.
 Union Electric Light & Power Company, St. Louis, Mo.
 United Drug Company, St. Louis, Mo.
 American Lithographing Company, Buffalo, N. Y.
 DuPont Fibre Silk Company, Buffalo, N. Y.
 Ralston Purina Mills, Buffalo, N. Y.
 Russell-Miller Milling Company, Buffalo, N. Y.
 Carborundum Company, Niagara Falls, N. Y.
 Eastman Kodak Company, Rochester, N. Y.
 Rochester Gas & Electric Corporation, Rochester, N. Y.
 Yawman & Erbe Mfg. Company, Rochester, N. Y.
 General Electric Company, Schenectady, N. Y.
 Otis Elevator Company, Yonkers, N. Y.
 Wiscasset Mills, Albemarle, N. C.
 Tallassee Power Company, Badin, N. C.
 Carolina Bakery, Charlotte, N. C.
 Chadwick-Hoskins Mills, Charlotte, N. C.
 Durham Hosiery Mills, Durham, N. C.
 Proximity Mills, Greensboro, N. C.
 Revolution Cotton Mills, Greensboro, N. C.
 Cabarrus Cotton Mills, Kannapolis, N. C.
 Cannon Mills, Kannapolis, N. C.
 Goodyear Tire & Rubber Company, Akron, Ohio.
 Lunkenheimer Company, Cincinnati, Ohio.
 National Acme Company, Cleveland, Ohio.
 Sharon Steel Hoop Company, Youngstown, Ohio.
 Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.
 Bethlehem Steel Company, Lebanon, Pa.
 McKeesport Tin Plate Company, McKeesport, Pa.
 Standard Sanitary Mfg. Company, New Castle, Pa.
 H. C. Aberle, Philadelphia, Pa.
 Freihofer Baking Company, 24th & Master Streets, Philadelphia, Pa.
 Freihofer Baking Company, 20th & Indiana Avenue, Philadelphia, Pa.
 General Baking Company, Philadelphia, Pa.
 General Electric Company, Philadelphia, Pa.
 Philadelphia Carpet Mills, Philadelphia, Pa.
 Philadelphia Electric Company, (Delaware Station), Philadelphia.
 Philadelphia Electric Company, (Thurlo Station), Chester, Pa.
 Philadelphia Electric Company, (New Richmond Station), Philadelphia, Pa.
 A. M. Byers Company, Pittsburgh, Pa.
 National Tube Company, Pittsburgh, Pa.

William Luden, Inc., Reading, Pa.
 Jones & Laughlin Steel Company, Woodlawn, Pa.
 H. & B. American Machine Company, Paw-

tucket, R. I.

Pacific Mills, Columbia, S. C.
 Woodruff Cotton Mills, Woodruff, S. C.

OFFICE BUILDINGS

Texarkana National Bank Building, Texarkana, Ark.

Southern California Telephone Company, Los Angeles, Calif.
 Pacific Telephone & Telegraph Company, San Francisco, Calif.

Continental Oil Building, Denver, Colo.
 Mountain States Telephone & Telegraph Company, Denver, Colo.
 Patterson Building, Denver, Colo.

Homer Building, Washington, D. C.
 Munsey Building, Washington, D. C.

Tribune Tower, Chicago, Ill.

Wild Bank Building, Indianapolis, Ind.

Merchants National Bank Building, Cedar Rapids, Iowa.

Santa Fe Office Building, Topeka, Kans.

Giddens Lane Building, Shreveport, La.
 Slattery Building, Shreveport, La.

Baltimore & Ohio Central Building, Baltimore, Md.
 Citizens National Bank Building, Baltimore, Md.
 Continental Trust Building, Baltimore, Md.
 Hearst Tower Building, Baltimore, Md.
 Maryland Casualty Building, Baltimore, Md.
 Munsey Building, Baltimore, Md.

New Chamber of Commerce Building, Boston, Mass.

Free Press Building, Detroit, Mich.
 General Motors Building, Detroit, Mich.
 Metropolitan Building, Detroit, Mich.
 Stroh Building, Detroit, Mich.

Central State Life Building, St. Louis, Mo.
 Federal Reserve Building, St. Louis, Mo.
 Missouri State Life Building, St. Louis, Mo.
 Missouri Theatre Building, St. Louis, Mo.

Paul Brown Building, St. Louis, Mo.
 Planters Building, St. Louis, Mo.
 Southwest Bell Telephone Company, St. Louis, Mo.

Medical Arts Building, Omaha, Nebr.
 Union Pacific Railroad Building, Omaha, Nebr.
 Woodmen of the World Building, Omaha, Nebr.

First National Bank Building, Albuquerque, N. Mexico.
 New York Telephone Company Building, Brooklyn, N. Y.
 Genesee Building, Buffalo, N. Y.
 Walbridge Building, Buffalo, N. Y.
 Singer Building, New York, N. Y.
 Chemical National Bank Building, New York, N. Y.

Professional Building, Raleigh, N. C.

Municipal Building, Akron, Ohio.
 Dixie Terminal Building, Cincinnati, Ohio.
 Union Central Building, Cincinnati, Ohio.
 Guardian Building, Cleveland, Ohio.
 Union Trust Building, Cleveland, Ohio.

Northwestern Bank Building, Portland, Ore.

Bell Telephone Building, Harrisburg, Pa.
 Bell Telephone Company, Philadelphia, Pa.
 Public Ledger Building, Philadelphia, Pa.
 Frick Building & Frick Annex, Pittsburgh, Pa.
 Gazette Times Building, Pittsburgh, Pa.
 Union Arcade Building, Pittsburgh, Pa.
 Union National Bank Building, Pittsburgh, Pa.

State National Bank Building, Corsicana, Texas.
 Magnolia Building, Dallas, Texas.
 Medical Arts Building, Dallas, Texas.
 Adams Building, Port Arthur, Texas.

Columbian Mutual Tower Building, Memphis, Tenn.

Coal Exchange Building, Huntington, W. Va.

New Sun Life Assurance Building, Montreal, Quebec, Canada.

PUBLIC BUILDINGS

Union Station, Washington, D. C.
 Santa Fe Railway Station, Emporia, Kans.
 Southern Railway Station, New Orleans, La.
 U. S. Court House & Post Office, Baltimore, Md.
 Nebraska State Capitol Building, Lincoln, Nebr.
 U. S. Post Office, Lincoln, Nebr.
 Hall of Records, New York, N. Y.

Municipal Building, New York, N. Y.
 New York County Court House, New York, N. Y.
 U. S. Post Office, Portland, Ore.
 Free Library Building, Philadelphia, Pa.
 City-County Building, Pittsburgh, Pa.
 Union Station, Toronto, Ontario, Canada.

SCHOOLS AND COLLEGES

United States Naval Academy, Annapolis, Md.	University of Oregon Medical Building, Portland, Ore.
Johns Hopkins School of Hygiene, Baltimore, Md.	Kutztown State Normal School, Kutztown, Pa.
Mount St. Agnes College, Baltimore, Md.	Millersville State Normal School, Millersville, Pa.
Technical High School, Omaha, Nebr.	Scottish Rite Dormitory for Girls, Austin, Texas.

STORES

Radin & Kamp, Fresno, Calif.	Hochschild, Kohn & Company, Baltimore, Md.
The May Company, Los Angeles, Calif.	The Hub, Baltimore, Md.
Daniels & Fishers, Denver, Colo.	Hutzler Brothers, Baltimore, Md.
Denver Dry Goods Company, Denver, Colo.	Bier Brothers, Buffalo, N. Y.
Brownley's Confectionery Stores, Washington, D. C.	Sibley, Lindsay & Curr, Rochester, N. Y.
S. Kann's Sons Company, Washington, D. C.	The May Company, Cleveland, Ohio.
Lansburgh & Brother, Washington, D. C.	Wm. Taylor & Son, Cleveland, Ohio.
Woodward & Lothrop, Washington, D. C.	Gimbel Brothers, Philadelphia, Pa.
Killian Store, Cedar Rapids, Iowa.	Strawbridge & Clothier, Philadelphia, Pa.
Bernheimer-Leader Stores, Baltimore, Md.	Sanger Brothers, Dallas, Texas.

GOVERNMENT BUILDINGS

Department of Agriculture, Washington, D. C.	U. S. Department of Fish & Fisheries, Washington, D. C.
Department of Commerce, Washington, D. C.	U. S. Government Printing Office, Washington, D. C.
Department of the Interior, Washington, D. C.	U. S. Naval Hospital, Washington, D. C.
Executive Mansion, (White House), Washington, D. C.	U. S. Naval Observatory, Washington, D. C.
Library of Congress, Washington, D. C.	U. S. Naval Proving Grounds, (Indian Head, Md.)
National Museum, Washington, D. C.	U. S. Navy Department Building, Washington, D. C.
Quartermaster Corps, U. S. Army, Munitions, Washington, D. C.	U. S. Patent Office Building, Washington, D. C.
Walter Reed General Hospital, Washington, D. C.	U. S. Senate & House Office Building, Washington, D. C.
U. S. Bureau of Engraving & Printing, Washington, D. C.	U. S. Soldiers Home, Washington, D. C.
U. S. Bureau of Standards, Washington, D. C.	U. S. Treasury Department, Washington, D. C.
U. S. Capitol, Washington, D. C.	State War & Navy Department Building, Washington, D. C.
U. S. Coast & Geodetic Survey, Washington, D. C.	

HOSPITALS

A. T. & S. F. Ry. Co. Coast Lines Hospital, Los Angeles, Calif.	Blodgett Hospital, Grand Rapids, Mich.
New Providence Hospital, Oakland, Calif.	Butterworth Hospital, Grand Rapids, Mich.
Sisters Hospital, Sacramento, Calif.	St. Mary's Hospital, Grand Rapids, Mich.
Sibley Hospital, Washington, D. C.	St. Joseph's Hospital, Kansas City, Mo.
St. Mary's Hospital, Evansville, Ind.	Liberty Hospital, St. Louis, Mo.
St. Joseph's Infirmary, Louisville, Ky.	Missouri Pacific Hospital, St. Louis, Mo.
Hebrew Hospital & Asylum, Baltimore, Md.	St. John's Hospital, St. Louis, Mo.
Johns Hopkins Hospital, Baltimore, Md.	St. Mary's Hospital, St. Louis, Mo.
Mercy Hospital, Baltimore, Md.	A. T. & S. F. Railway Hospital, Albuquerque, N. Mexico.
Union Memorial Hospital, Baltimore, Md.	Babies & Maternity Hospital, Cleveland, Ohio.
Massachusetts General Hospital, Boston, Mass.	Multnomah County Hospital, Portland, Ore.
Henry Ford Hospital, Detroit, Mich.	West Penn Hospital, Pittsburgh, Pa.
	Reading Hospital, Reading, Pa.

MISCELLANEOUS

Pacific Southwest Bank, Fresno, Calif.	Church Home & Infirmary, Baltimore, Md.
Hellman Bank, Los Angeles, Calif.	Geo. B. Evans Warehouse, Philadelphia, Pa.
A. T. & S. F. Railway Company Shops, San Bernardino, Calif.	First Baptist Church, Dallas, Texas.
Elite Laundry, Washington, D. C.	Rice Institute (Chemical Building), Houston, Tex.

The Armstrong Line

ARMSTRONG'S CORKBOARD—for the insulation of cold storage plants, roofs, residences, tank cars, etc.

NONPAREIL CORK COVERING—for all cold lines

NONPAREIL HIGH PRESSURE COVERING, BLOCKS AND CEMENT—for steam lines, boilers, furnaces, ovens, etc.

NONPAREIL AND ARMSTRONG'S INSULATING BRICK—for boiler settings, kilns, furnaces, etc.

NONPAREIL STILL INSULATION—for pressure stills and other refinery equipment

ARMSTRONG'S NONPAREIL MACHINERY ISOLATION—for deadening vibration and noise under fans, motors, machinery, etc.

ARMSTRONG'S CORK TILE—for floors in banks, libraries, churches, offices, etc.

LINOTILE FLOORS—for offices, banks, public buildings and halls, homes, etc.

CIRCLE A CORK BRICK—for dairy barns and hog houses

ARMSTRONG'S LINOLEUM—plain, printed, inlaid, linoleum rugs, etc.

ARMSTRONG'S CORKS—of all descriptions

KORXOLE—flexible cork innersoling for shoes

ARMSTRONG'S CORK GASKETS AND WASHERS—for automobiles and other machinery

ARMSTRONG'S SEAMLESS CORK COTS—for covering textile rolls

ARMSTRONG'S CORK BOX TOES—for soft toes in shoes

Bungs and Taps

Insoles

Handles

Carburetor, Oil and Gasoline Floats

Bath and Table Mats

Life Preservers

Buoys

Yacht Fenders

CORK SPECIALTIES OF EVERY DESCRIPTION

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